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THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XLII.—*On a Group of Visual Phenomena depending upon Optical Errors of the Human Eye;* by CHARLES S. HASTINGS.

IN two preceding articles* the writer has contributed measurements which serve to define the average human eye, both with respect to its color error and its error of collimation, to a closer degree of approximation than that of Helmholtz and his successors as embodied in the well known *schematic eye.* The aim of this paper is to discuss certain consequences which may be based upon these more exactly determined data and to describe, and explain as far as practicable, a number of visual phenomena not thoroughly studied heretofore, or, perhaps, wholly known. For this purpose we require, in addition to the elements established in the papers cited, a knowledge of the positions of the external and internal pupils of the model eye. By the former term is meant the virtual image of the real pupil as formed by refraction at the cornea; and by the latter, the virtual image of the real pupil as formed by successive refractions at the anterior and posterior surfaces of the lens. These are evidently so related to each other that a ray from an object outside to a point in the exterior pupil will correspond to a ray from the corresponding point in the interior pupil to the image of the object. If we take, as in the preceding articles, the vertex of the cornea as the origin of coördinates, together with the place of the center of the real pupil as established in the second paper, a simple calculation shows that the centers of the pupils are at 0·3046^{cm} and 0·3705^{cm}, respectively, both lying on the nasal side of the axis

* This Journal, vol. xix, p. 205 and p. 310.

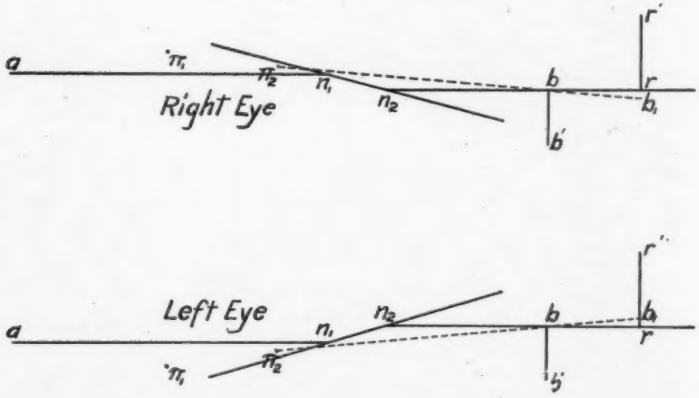
of symmetry and approximately midway between these axes and the axes of vision. These values are for wave-lengths of mean refrangibility, the variations in the values for different wave-lengths not being of moment for our present purposes; the small difference in relative size of the two pupils is also ignored as immaterial.

The elements of the schematic eye, so far as they are necessary to our investigation, are:

$a = 4°{\cdot}2$	Dist. π_1 to $\pi_2 = 0{\cdot}0659^{cm}$
Dist. π_2 to $n_1 = 0{\cdot}3264^{cm}$	" n_1 to $n_2 = 0{\cdot}0357^{cm}$
" n_2 to retina $= 1{\cdot}55^{cm}$	" F_b to $F_r = 0{\cdot}0566^{cm}$

These elements are represented in fig. 1, in which, for the sake of perspicuity, the scale is greatly distorted by increasing those

1



of the first column in the ratio of 2·5 to 1 and those of the second column in the ratio of 25 to 1. With this qualification fig. 1 represents accurately the necessary elements of a pair of normal eyes, the lines $n_1 n_2$ being the axes of the eyes, the lines $a\,n_1$ the external, and $n_2 r$ the internal lines of vision, and the points π_1 and π_2 the positions of the centers of the external and internal pupils, respectively. The points b and r are the positions of the images of a distant object on the line of vision for two wave-lengths of light corresponding to a difference of refrangibility in water of ·0100, which corresponds to an interval in spectral colors nearly equivalent to that separating C and G.

I. *Utility of Error of Collimation.*

Suppose both eyes directed to a distant surface divided vertically into two portions of which the left side is red and the right blue, the point of fixation for each eye being on the line of demarcation. In this case the image of the red surface would be represented by the line $r\,r'$ in each eye and that of the blue surface would be represented by the lines $b\,b'$, If the eyes were sharply focussed for red light, that is, if the retinas corresponded with the surfaces $r\,r'$, the observer would have a sharply defined image of the boundary in red and an ill-defined image in blue as the resultant effect of the diffusion circles due to the chromatic aberration of the eye. The diameter of these diffusion circles will bear the same ratio to the diameter of the interior pupil as the distance $b\,r$ does to $\pi_2 b$, while the centers of these diffusion circles corresponding to points at the boundary between the colored fields will lie on a line on the retina which is represented in the diagram by the projection of this line, namely, by the point where the line $\pi_2 b$ extended intersects the retina. It is obvious from inspection that only from the line $\pi_2 b_1$ towards the nasal side in the right eye, and towards the temporal side in the left eye, do we have a full illumination of the retina equal to that of the blue field itself. We see, therefore, that in the case supposed there is a narrow region, relatively dark, bordering the sharply defined edge of the red image in the right eye, while in the left eye there is a corresponding region where the contrast is reduced by a commingling of the two colored lights.

It is easy to see that if the eye is adjusted for distinct vision of the blue surface, that is, if the retina corresponds to $b\,b'$ of the diagram, exactly the same conditions as regards sharpness of distinction hold as before. If the observer's attention were directed to this particular feature of the object, that is, to the dividing line in the field, he would inevitably accommodate either for the red or for the blue, and, ignoring the confused sensation of the left retina, recognize a sharpness of division which would be lacking if the right eye were symmetrical in construction. If the red and blue fields were interchanged the left eye would become the discriminating one.

Before we can attach great importance to this conclusion we must see if the relations quantitatively considered are such as to support it. To do this we must calculate the angular width of the darkened strip and of the radius of the diffusion circles; the first giving us a notion as to its conspicuousness as an interruption in the field of vision, and the second a notion as to its intensity. We read at once from the diagram that the true width of the region is—

$$\left\{ (n_2 - n_1) tg\, a + (\pi_2 - n_1) tg\, \tfrac{1}{2} a \right\} \frac{br}{\pi_2 b} .$$

If this quantity be divided by the distance from n_2 to the retina, we shall have its angular width. This is found to be equal to 1′, a conspicuous magnitude, since alternate bright and dark lines of half this angular width can be distinguished under favorable circumstances.

The second part of the problem is not quite definite because the radius of the pupil is not a constant; but if we assume a diameter equal to $0{\cdot}2^{cm}$ we shall be near the true value for ordinarily bright illumination. This assumption gives $6'{\cdot}8$ for the angular value of the radius of the diffusion circles; in other words, this is the angular width of the strip within which the illumination of the retina by blue light falls from its maximum to zero. As experiment shows that a diminution of luminous intensity of less than one per cent is obvious at a sharply defined border, there is no room for doubt that the peculiarity of construction does possess a useful function in vision, inasmuch as that with the established collimation errors we are enabled to detect boundaries of colored fields with a degree of precision which would be wanting in eyes without such errors.

This is a highly interesting reason for the persistence of a systematic optical error in the human eyes which is otherwise extremely difficult to account for, since no other possible error admits of correction so easily. If we recognize the advantage which the peculiar relation of the collimation errors in the two eyes gives to one searching for colored fruits or colored animals, we may be led to the conclusion that in an earlier state of racial development the peculiarity would have been more important than at present, and then, perhaps, to speculation as to whether it may not now be regarded as largely vestigial. This last idea would doubtless find support in the extraordinary irregularity of the constant of collimation in the sixty or more cases recorded.

II. *Geranium Phenomenon.*

This is a name given provisionally to a peculiar visual phenomenon with which I have been familiar for an indefinite time, although it does not seem to have ever been noted, or at least recorded, by other observers. It is not unlikely that relatively few persons are able to see it, but it is not a personal peculiarity. Briefly described the phenomenon is this: When-

ever I look at red geranium petals, in the brilliant light of out of doors, projected against the more remote background of its green leaves, the petals seem—in portions of the visual field at any rate—to be bordered with an exquisitely fine line of intense blackness, much more intense than that of black velvet under the same illumination. My eyes cannot make these black lines point of fixation for they are singularly elusive, but they are too delicate to be seen if they did not fall very near the axis of vision. Red petals of other flowers exhibit quite the same phenomena, notably red nasturtiums, but only strikingly when the green background is sufficiently luminous.

The more important general conclusions from such observations seem to be embodied in the following list:

(*a*) The phenomenon is monocular.

(*b*) The dark lines are conspicuous only when the illumination is intense (equals, probably, when the pupillary aperature is small).

(*c*) The contrasting colors must be well separated as regards refrangibility and of approximate equal brightness.

(*d*) The difference of the distances of the two colored fields from the eye must not be small compared to the distance of the nearer one.

By attention to these precepts I have been able to observe the same phenomenon with a considerable range of pure spectral colors as well as to prove that the order of the colors, as measured from the eye, is not essential. The reason that I see the black lines as described above, and no black border to a green leaf projected upon a red petal, is to be ascribed, probably, to the fact that my slightly myopic eye can form a sharp retinal image of the red when not more than one or two meters distant, while the green leaf would be notably out of focus.

A highly probable explanation of this phenomenon can, I think, be found from an inspection of fig. 1 above. Suppose the parti-colored object be shifted so that the line of demarcation falls on the line $n_1 \pi_1$ extended; then, in the right eye, r and b_1 will have approached each other, but will still be distinct. Now imagine the blue portion of the object carried a considerable distance farther from the eye on the line $n_1 \pi_1$ extended, then light from points in the blue object very near its edge will send light to only the outer, or temporal, half of the pupil, the inner half being shaded by the nearer red object. It is, however, just this latter half of the pupil that transmits the light which diffuses blue light on the temporal side of the line $\pi_2 b_1$, hence there is a region of the retina between r and b_1 in the right eye, upon which, under the conditions considered, no light falls on any color whatever. No doubt such an

unilluminated portion of the retina, if it caused any visual perception, would be interpreted as a line of more than absolute external blackness.

In the case of the model eye the breadth of the dark band would be considerably less than one minute of arc and at a distance of about two degrees from the point of most distinct vision, hence it is perhaps doubtful whether it could be perceived as a black line. In the case of my own eyes the constant of collimation is about half that of the normal eye and the pupils are nearer the axis of vision. From these data we may estimate the angular value of $r\,b_1$ for my eyes, as something less than one half minute of arc at the *fovea centralis*. The value for the interval red-green may be regarded as half this value; and finally, at the eccentric position where the strip on the retina is wholly unilluminated this must be again reduced by an amount which could be determined accurately only when the constants of the eye are known with a greater precision than now attained. It is probable, however, that this value would not be less than ten seconds of arc. Whether a strip of the retina of a width only one sixth of the ultimate perceptual elements of vision would, when deprived of light, give rise to a conspicuous sensation, is a question which, as far as I can find, has not been considered by investigators in this field. It has been abundantly proved that the ultimate precision of optical definition, under the most favorable circumstances, is not less than 60″; on the other hand, there is obviously no minimum limit for the angular width of a bright line for visibility, since this is only a question of the amount of light received by the eye, or of its brightness. But the question of how narrow a black line on a bright field can be seen is wholly different. My own experiments, although of great simplicity, seem to be perfectly adequate for our present purposes. I found that I could see a black hair of a measured diameter of 0·0025 inch as a black line, against a sky of favorable brightness, up to a distance of 300 inches. At the greatest distance the angular width is only 1″·72. There is, therefore, no difficulty in adopting the above explanation of the phenomenon under discussion even if we were obliged to assume a much smaller value for the area of unilluminated retina.

A familiar example of this same phenomenon, if I am not mistaken, is presented to us by the appearance of a red billiard ball on a green table. Here the vertical contours of the ball are astonishingly sharp as compared to that of the upper surface, and also to what we might expect from the pronounced chromatic aberration of the eye.

III. *Phenomenon of "Fluttering Hearts."*

This phenomenon, upon which much has been written, is thus described by Helmholtz:*—"A peculiar phenomenon, which perhaps belongs in the same domain as that of the flickering rotating disks, is that of the so-called fluttering hearts. On a colored sheet of stiff paper are placed figures of another vivid color; red and blue seem to yield the best results—the colors must be very vivid and saturated. If one looks at the sheet while it is moved to and fro with a certain quickness, the figures seem to move themselves and to shift forwards and backwards on their support. The cause of this appearance seems to depend upon the fact that the visual impression for different colors does not originate and die out with equal quickness, and consequently the blue appears left somewhat behind the red in the path described by the sheet."

Numerous experiments with a considerable number of observers made in accordance with this description proved wholly futile. Small disks of vividly colored paper scattered upon strongly contrasting grounds were tried under greatly varying circumstances of illumination and of observer without once succeeding. It was only after one of my colleagues brought me a particular book having green and black lettering printed upon a red cover, both colors being nearly saturated and of approximately equal luminosity, that the real phenomenon could be observed by me and exhibited to others. Even in this case it could not be recognized in a good illumination, either by day light or by artificial light, when the lighting was such that the texture of the surface and outlines of the green letters was well seen; but when illuminated by a single source of light, sufficiently remote so that the sharpness of the green letters was lost, the effect became absolutely startling—the green letters appearing to slip about among the black in a most unaccountable way. The astonishment shown by all to whom I have exhibited this optical illusion is a sufficient proof of its rarity in ordinary experience.

The indicated conditions of success in the experiment seem to be these:—

(*a*) The saturated colors must differ widely in refrangibility and not too widely in luminosity.

(*b*) The position of one of the colors in the visual field must be well determined—as by the sharply printed black letters in the object described—while the other must have its outlines ill defined.

With attention to these precepts I have been able to secure the illusion invariably with every one with whom I have experi-

* Helmholtz, Physiol. Opt., 2te Aufl. p. 533.

mented. By isolating small pieces of colored paper by a black border from the red background I have been able to show the peculiar shifting in question for various hues of green, blue, and ultramarine blue. Sometimes when not obvious to direct vision it becomes striking to averted vision.

The explanation, it seems to me, may be found in the differing angular velocity with which the images of different colors move over the retina. This difference can be readily calculated in the following method.

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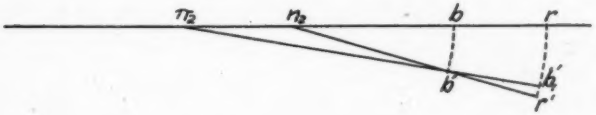


Let the object move so that its image (fig. 2) in red light shifts its position from r to r'; the corresponding image in blue light will shift from b to b', while the center of the diffusion circle on the retina, supposed to be at r for convenience, shifts from r to b'_1. It is at once obvious that $rr'/bb' = n_2 r/n_2 b$; also $bb'/rb_1' = \pi_2 b/\pi_2 r$; whence $rr'/rb_1' = n_2 r \cdot \pi_2 b/n_2 b \cdot \pi_2 r$. From the table of dimensions given above this ratio is found to equal 1·0072; that is to say, when an object having red points is shifted in the visual field, the red points seem to have an angular velocity and an angular acceleration about three-fourths of one per cent greater than that of accompanying blue points. Thus, when the red surface described in the experiment is suddenly set in motion, the eye, for an instant fixed, judges of its acceleration and of the less acceleration of the green; then, following it in its motion until it is arrested, concludes that the more refrangible color is left behind—a false judgment which is corrected by the sense of a gradual approach of the green to its true position of rest, just as when the eyes, observing a procession of points passing fixed points, corrects a false judgment as to the place of the former, when the motion suddenly ceases, by an apparent temporary motion in the opposite direction. Of course, if we gain our notion of the angular velocity of the green areas from sharp visual perceptions of their boundaries, the illusion ought not to appear; it is only when the position of the colored area is recognized by its color alone that the effect becomes striking; hence the significance of faint illumination.

IV. *Binocular Color Relief.*

This is an optical illusion not noted in Helmholtz but described and studied at length by W. Einthoven, who was incited to the investigation by Donders.* According to this writer, Professor Donders was the first one to record the fact that red and blue objects in the same plane appear to most observers, when looked at with both eyes, to lie in different planes, especially when on a black background. To him, as well as to Einthoven, the red appears nearer than the blue. The explanation offered by Einthoven can be described by reference to fig. 1 above. Imagine both axes of the vision converged towards a red point which is accompanied by a blue point just above it: the red images would fall on the points of distinct vision, while the centers of the diffusion circles for blue would fall on disparate points of the retinas nearer the median plane, just where sharp images of a more distant red point would fall; hence the interpretation of the resulting sensation is that the blue point is in fact more remote. He finds evidence in favor of this view by the ingenious experiment of cutting off, by means of movable diaphragms in front of the eyes, first the inner halves of the pupils and then the outer; by this means he enhances or inverts the illusion. His experiments are easily repeated and are highly interesting.†

There are, however, serious objections to this explanation, not only as accounting for the observations, but also from theoretical considerations. Of about thirty individuals investigated Einthoven found that nearly one-third were not confident at first that there was any sensation of relief, while ultimately about half recognized the relief as did Donders, and the other half inferred an inverted order. This general conclusion is fairly well supported by my own more limited experiments. According to the theory, we are obliged to conclude that half of those investigated had the centers of their pupils lying on the nasal side of the axes of vision, and half on the temporal. It is, however, quite certain that a displacement of the pupil towards the nasal side of the axis of vision

* Stereoskopie durch Farbendifferenz. Graefe's Arch., xxxi (3).

† A convenient and interesting modification of this experiment may be made by observing a flat surface divided into separated areas of saturated colors through a binocular telescope of which the separation of the axes can be varied at will. The familiar prismatic binoculars are best adapted to the purpose, and any mosaic glass window in which the colors are vivid forms a far better object than colored pigments. If the axial separation is a little greater than that of the eyes, a striking relief will be observed in the sense described above, while a smaller separation will invert the relief.

is extremely rare; consequently there seems to be no escaping the conclusion that similar visual impressions receive, not merely unlike, but opposite interpretations in different individuals. Any acceptable theory must adapt itself to this fundamental fact.

It seems to me that we can find a probable explanation in the following considerations. Imagine a number of red points distributed in two parallel planes which lie at right angles to their direction from the observer. If the eyes be fixed upon one of the points in the nearer plane, the images of all the other points in that plane will fall on pairs of congruent points of the two retinas, but the images of the points on the more remote plane, which will be quite sharp if the separation of the planes is moderate, will fall on disparate points of the two retinas. Now consider the case of red and blue points in a single plane. Here, if the eyes be fixed upon one of the red points, all the other red points will have their images on congruent points of the right and of the left retina, while the blue points, relatively very diffuse as compared to the images of the more distant red points in the former case, will fall on disparate points. So far there is a formal similarity between the two cases, but it cannot be carried further: in the first case a simple change of convergence of the axes of vision will change the disparate points to congruent, and *vice versa*, while in the second case no such change can produce such an effect; but a change of accommodation proper to blue light will do so at once. The resemblances and differences are such, therefore, that it should hardly surprise us that certain persons recognize the second case as only a confusion of visual images, when others interpret the effect as a sort of chromatic relief; nor is it astonishing that of the latter group, since there is really no fundamental relation between the two phenomena, some should imagine the red to be nearer than the blue points and others invert the order. It is singular, however, that Einthoven found those whom he observed to be distributed so nearly equally among the three classes.

The experiments of restricting the pupils by screens in front of the eyes is by no means conclusive; indeed, it is questionable whether it has any bearing whatever upon the phenomenon. The screens will, primarily, increase very greatly the separation of the centers of the red and blue areas on the retinas which represent the images of the points; moreover, the areas themselves will be much decreased. This will become evident from an inspection of fig. 1. But, as is easy to prove by a diagram, any lateral change of the common point of fixation will produce a relative change in the position of the colored areas on

the retinas, which can be compensated by an alteration in the convergences of the axes, and thus the phenomenon is reduced to one which admits of a simple stereoscopic interpretation in complete accordance with the observations. This is because such a shifting—whether produced by a change in the direction of vision or by a change of place in the object itself—partially uncovers one pupil while increasing the obstructed portion of the other, in short, virtually moves one pupil inwards and the other outwards. The resultant effect is like that produced by placing a thin wedge of glass before one eye, when the red appears in advance of the blue if the thicker edge of the wedge is on the nasal side; a reversal of the wedge inverts the apparent relief.

There is, however, one phenomenon which often gives a determining impulse to the interpretation in accordance with the experience of Donders, namely, the relative angular displacement of different colors upon the retina. Thus, in my own case, although quite unable to recognize anything like stereoscopic relief among a series of strongly colored figures on a black background when the eyes are fixed pretty steadily upon them, the relief appears very striking when I walk past it, or when the object as a whole is moved to and fro. So too, in the experiment of the fluttering hearts described above, although there is no chromatic relief under ordinary illuminations, such relief is an invariable accompaniment of the fluttering when produced. As has been shown above, the angular accelerations and angular velocities of moving objects in the visual field would vary with their color, so that colors of greater refrangibility would appear to change their directions from the observer more slowly, exactly imitating in this particular the effect of greater distance.

The illusion described would appear of rather abstract scientific interest were I not convinced that the incomparable French artists of the thirteenth century had recognized it and employed it for the purpose of artistic expression. Indeed, it was a casual inspection of the marvelous medieval windows in the great cathedral at Bourges which first turned my attention to the studies embodied in these papers, and which persuaded me that the one essential distinction between these antique windows and their unsatisfactory modern imitations lies in the knowledge, possessed by the old artists, of the effect gained by an ordering of their vivid colors so that the resulting chromatic binocular relief should fit the composition of their pictures. As far as known to me, the most beautiful surviving examples of this lovely art, as well as the most convincing support for the views here presented, are contained in that unapproached

collection; and not alone in the wonderful achievements of those forgotten artists, but also in the instructive failure which has attended modern restorations.*

This is not the place to suggest reasons why so charming an art should hardly have survived the thirteenth century, nor to discuss certain peculiar restrictions to which the artists subjected themselves; but were such an extention of this paper desirable, it seems to me that it would add material weight to the explanation, founded upon principles of physiological optics, of the acknowledged superiority of antique mosaic windows over their modern imitations.

*In two quadrifoils in the window given by the Guild of Tanners the artist has chosen a red background in place of the almost universal blue; but he has reversed the order of his colors throughout the composition so that the effect, to my eyes at least, was that of two charming little intaglios. It was this which first suggested to me the distinction between ancient and modern mosaic windows described above and which I thought abundantly verified by subsequent observations. Certain very puzzling contradictions to this theory—I have no means now of determining how many—were eliminated by a subsequent discovery that considerable areas of some of the windows are nineteenth century substitutions for the original designs which had been lost. There was no suggestion of this significant fact in my hands at the time of my visit.

Yale University, May, 1905.

Art. XLIII.—*On the Natural Iron-Nickel Alloy, Awaruite;* by George S. Jamieson.

Two terrestrial iron-nickel alloys from adjoining localities will be described in this paper. One from Josephine Co., Oregon, which has already been investigated by Mr. W. H. Melville,* came through Mr. Maynard Bixby of Salt Lake City, Utah. The other, found at South Fork, Smith River, Del Norte Co., California, was from Dr. David T. Day, Chief of the Division of Mining and Mineral Resources of the United States Geological Survey. Both specimens had been sent to Professor S. L. Penfield, at whose advice this investigation was undertaken.

The specimens from Josephine County were water-worn, bean-shaped pebbles, varying in size from a few millimeters to two centimeters in diameter and were composed not only of the alloy, but also of more or less siliceous matter. Thin sections showed that the alloy was of a spongy nature, binding together and enclosing particles of silicate, which had the appearance of serpentine and gave the chemical reactions for that substance. In a steel mortar, the pebbles were easily broken into a powder and no mechanical method of making a separation of the metal from the serpentine seemed possible. A chemical separation, however, was easily effected by treating the powder with water and iodine at ordinary temperature. A complete solution of the alloy was thus obtained in about a day, while the siliceous matter was not dissolved by this treatment. The insoluble silicate was filtered on asbestos, air dried, and weighed. Duplicate analyses were made with the following results:

Insoluble silicate	24·15	24·55
Iron	19·17	18·95
Nickel	56·30	56·07
Cobalt	·35	·35
Phosphorus	·04	·04
Sulphur	·09	·09
	100·10	100·05

Deducting the insoluble silicate and recalculating the remaining constituents to one hundred parts, the following percentages were obtained:

Iron	25·24	25·11
Nickel	74·17	74·30
Cobalt	·46	·46
Phosphorus	·04	·04
Sulphur	·09	·09
	100·00	100·00

* This Journal [3], xliii, 509.

These results differ but slightly from those obtained by Melville, who found iron 23·22, nickel 60·45, and 15·83 per cent of other constituents. The metals calculated to 100 per cent equal, iron 27·75, and nickel 72·25.

The sample of iron-nickel alloy which came from Smith River, California, was in the form of grains of remarkably uniform size, about 0·15 millimeters in diameter, with an occasional larger grain, up to 1·5 millimeters. The metallic sand, for that is what it appears to be, was obtained from gold washings and was chiefly composed of the alloy, but mixed with magnetite, and a very little chromite. As no mechanical method for separating the alloy from the magnetite seemed to give satisfaction, a separation by chemical means was again resorted to. The size of the grains, which could not be reduced to powder, made the solution in iodine altogether too slow for practical purposes. The alloy was found, however, to be easily soluble in warm dilute nitric acid (one part conc. HNO_3: two parts H_2O), while the magnetite was not appreciably attacked, if at all. Duplicate analyses were made with the following results:

Insoluble matter	9·45	9·97
Iron	19·21	18·97
Nickel	68·61	68·46
Cobalt	1·07	1·07
Copper	·59	·56
Sulphur	·05	·05
Phosphorus	·04	·04
Silica	·10	·19
Magnesium oxide	·50	·44
	99·62	99·75

The specific gravity was found to be 7·45 or, allowing for 9·7 per cent of magnetite, the value 7·85 is obtained for the alloy.

Deducting the insoluble matter, consisting of the magnetite, a small amount of chromite and the traces of silica and magnesium oxide, and recalculating the remaining constituents for one hundred parts, the following percentages were obtained:

Iron	21·45	21·28
Nickel	76·60	76·79
Cobalt	1·19	1·20
Copper	·66	·63
Phosphorus	·04	·04
Sulphur	·06	·06
	100·00	100·00

In dissolving the alloys in hydrochloric acid, it was noted that there was no odor of hydrocarbons, such as is observed when iron and steel are dissolved, nor was there any evidence of graphitic carbon.

These two iron-nickel alloys are quite similar in composition to those which have already been described from other localities, and for comparison, a table has been arranged to show percentages of iron and nickel which these various alloys contain. The first analysis is that of an alloy found at Gorge River, which flows into Awarua Bay on the west coast of South Island, New Zealand, described by W. Skey* in 1885 and to which the name awaruite was given. The second analysis, by A. Sella,† is of an alloy from the gold-bearing sand of the Elvo River, near Biella, Piedmont, Italy. The third analysis, by Melville, is of material from Josephine Co., for which the name Josephinite was suggested. No. 4 is a recent analysis by F. G. Wait, quoted by G. C. Hoffmann,‡ of a similar alloy from Fraser River, British Columbia, to which Hoffmann has given the name souesite, as stated by him, "to distinguish this find from that of other naturally occurring iron-nickel alloys." The last two analyses are those of the present writer.

	Locality.	Analyst.	Fe.	Ni.	Co.	Cu.	Other constituents.
1.	New Zealand	Skey	31·02	67·63	·70	none	·63
2.	Piedmont, Italy	Mattirolo	26·60	75·20§	..	none	..
3.	Josephine Co.	Melville	27·41	71·35	·65	·59	..
4.	British Columbia	Waite	22·30	76·48	none	1·22	..
5.	Josephine Co.	Jamieson	25·24	77·17	·46	..	·13
6.	Del Norte Co.	"	21·45	76·60	1·19	·59	·10

It is seen from a glance at the analyses of the alloys from the five different localities, that there is a certain uniformity in composition, but that they are not a definite compound of iron and nickel is evident, nor would this be expected; with Fe : Ni = 1 : 3, the percentages are Fe 24·00 and Ni 76·00, to which most of the analyses approximate, while for the ratio 1 : 2 the values are Fe 32·19 and Ni 67·81. It seems unfortunate that so rare a substance should have received three distinct names, awaruite, josephinite, and souesite, and it is urged that awaruite, which has priority, should alone be used.

As regards the occurrence of the alloy, its association at Josephine Co., Oregon, with serpentine, and at New Zealand, Piedmont, Frazer River, and Del Norte Co., Cal., with chromite, suggests that it is a material which has separated from basic peridotite rocks, and, as it seems to have no tendency to deteriorate by oxidation, it is found as a heavy constituent in adjacent river sands.

In closing, it is desired to thank Mr. Bixby and Dr. Day for the material which they had sent to the laboratory for investigation, and also Professor S. L. Penfield for his help and valuable suggestions.

Sheffield Scientific School of Yale University, May, 1905.

* Trans. N. Zeal. Inst., xviii, 401. † Comp. Rend., cxii, 171.
‡ This Journal (4), xix, 319, 1905. § Contains cobalt.

ART. XLIV.—*Hyopsodidæ of the Wasatch and Wind River Basins;* by F. B. LOOMIS.

DURING the early summer of 1904, Amherst College sent a party into the Wasatch along the Big Horn River, where an unusually complete collection was obtained: later, collecting was continued in the Wind River beds, a new and rich locality having been found on the east side of Bridger Creek, about ten miles northwest of Lost Cabin Post Office, Wyoming. In the latter basin, the fauna of which has been but meagerly known, some 400 specimens, distributed among about 50 species, were found. As a large number of the species are new, the material, together with that of the Wasatch, has been used in a study of the families represented; reference also having been made to other collections from these horizons, especially those of Cope and the American Museum of Natural History, both being in that museum.

Order INSECTIVORA.

Family *Hyopsodidæ*, Schlosser.

This family as now known includes two genera, *Hyopsodus* and *Sarcolemur*, both from the North American Eocene. The genera were originally classed among the Primates; and so in Cope's* and Osborn's† papers are placed under the suborder Mesodonta; or by Schlosser‡ under the equivalent Pseudolemuroidea. Wortman,§ however, has classed them among the Insectivora, giving the following reasons: 1, the incisors are 3/3; 2, the tympanic bulla is not ossified; 3, the structure of the molars is not Primate; 4, the enterocarotid circulation is that typical of the Insectivora: 5, the limb bones differ from those of any known Primate; 6, the metapodials are not Primate; 7, the phalanges are short; 8, the hallux is not opposable. The writer too would place the Hyopsodidæ among the Insectivora and in the neighborhood of the genus *Erinaceus*.

The family may be defined as follows: teeth in a continuous series, cusps more or less pointed; superior molars with intermediate cusps (protoconule and metaconule); posterior internal cusp (hypocone) less developed than the other cusps; the lower molars with a low anterior buttress (protolophid) connecting the two anterior cusps; a second buttress behind the first, connecting the same cusps posteriorly (metalophid) more or less developed; the entoconid feebly developed (see fig. 1).

* Rep. U. S. Geol. Surv., iii, 738, 1884.
† Bull. Amer. Museum Nat. Hist., 178, 1902.
‡ Die Affen, Lemuren, Chiropteren N. S. W., 21, 1890.
§ This Journal, xv, 400, 1903.

Two genera are distinguished by Cope and Osborn on the condition of the metaconid: when simple, *Hyopsodus:* if bifid, *Sarcolemur*. The two genera are certainly distinct but further characters are required to separate them; for several jaws, which, in all other features, are most closely related to *Hyopsodus*, still have the metaconid bifid. This character has also been noticed as occurring in the genus *Eohippus*, *Phenacodus*, and *Systemodon*, and is not, therefore, considered alone enough to separate the two genera. The bifid metaconid is used below to distinguish some of the species of *Hyopsodus*.

Hyopsodus is characterized by lower wider teeth, the cusps being blunter; the fourth premolar is wide and not compressed, having fewer and less developed cusps. It occurs in the Wasatch, Wind River and Bridger horizons. In several species there is a tendency to have the metaconid bifid, but it is never as marked as is characteristic of *Sarcolemur*.

Sarcolemur is characterized by narrow trenchant teeth, with pointed cusps; the fourth premolar is much compressed and has the anterior cusps well developed. It is as yet known only from the Bridger, and of the promolars only the fourth is known.

Hyopsodus Leidy

Lemuravus Marsh, *Stenacodon* Marsh, *Microsus* Leidy, *Diacodexis*, Cope.

The genus was founded by Leidy* on an imperfect lower jaw of *H. paulus* from the neighborhood of Ft. Bridger. The name Microsus† was given the same year to a second species differing only in the proportionate depth of the mandibular ramus. Stenacodon‡ was founded by Marsh on what proves to be a last lower molar, the genus being separated on the ground that there was no cingulum. Lemuravus§ was proposed for a species on the basis of the incisor formula being 3/3 which, later, proved to be true for *Hyopsodus*. *Diacodexis*‖ was proposed by Cope for a specimen, including premolars of *Eohippus*. As yet the only members of the family found in the Wasatch and Wind River horizons belong to the genus *Hyopsodus*, the skeletal features of which are as follows:

The skull is elongate with a level top terminating abruptly behind, the rear of the cranium overhanging the occipital condyles, somewhat as in Rodent skulls. The zygomatic arches are slender but widely arched. On the deep lower jaw, the anterior border of the surface for attachment of the masseter

* Proc. Acad. Nat. Sci., Phila., 110, 1870.
† Same cit., p. 113.
‡ This Journal, ii, 210, 1892.
§ Same cit., vol. iv, p. 239, 1875.
‖ Proc. Amer. Phil. Soc., vol. xxi, 181, 1883.

muscle lies just under the last molar. The teeth are in a continuous series but without crowding. In the upper jaw, the hypocone of the last molar is merely a rudiment, indicated by a slightly raised portion of the cingulum. Molars one and three have a small but distinct hypocone, the cingulum running to it. The first and second premolars have a single cusp while the third and fourth each have inner cusps. The canines are moderate and the three incisors simple. Specific characters are found only in the cingulum and size of the form. The lower teeth are more varied, especially the last molar. The general topo-

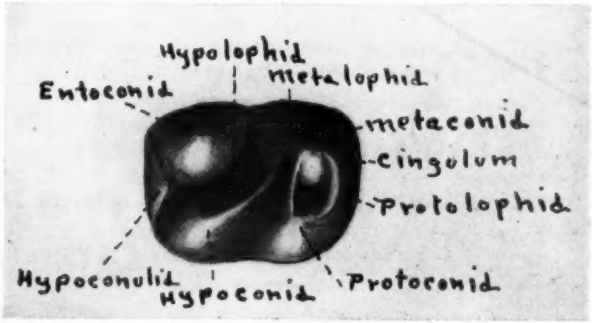


FIG. 1. A typical Hyopsodus lower molar. × nat. size.

graphy of a lower tooth with the nomenclature here used is given in fig. 1. On the front part of the tooth the protoconid and metaconid are the principle cusps, connected anteriorally by a low curved protolophid. The inner end of this is in some species developed into a tiny cusp, the possible equivalent of the paraconid. Behind, these same two cusps are usually united by a metalophid, and the hypoconid is connected to the metaconid by a more or less developed ridge (hypolophid). The entoconid is always feebly developed, and between it and the hypoconid there is a strong hypoconulid. The fourth premolar has the protoconid and deuteroconid well developed, and from the former a ridge runs to the front, while a second ridge runs from the same cusp to the rear, developing in some species one or two cusps on the margin. The third premolar is similar but simpler.

Of the milk dentition I have seen nothing which is worthy of note among so many specimens.

The skeletal material, while rather fragmentary, gives many of the characters which determine the ordinal position of genus. The stout humerus is widened at the distal end and pierced by a supratroclear foramen (similar to *Erinaceus*).

The olecranon process of the ulna is long (distinctly an Insectivor character), and the greater sigmoid cavity is very wide, the less sigmoid cavity being also well marked. The femur is short, thick and flattened, and has a strong third trochanter. (This is not found in Primates, but is especially well marked in *Erinaceus.*) Finally, according to Wortman, the metapodials are short and stout, and the hallus not opposable (both Insectivor features).

Hyopsodus simplex sp. nov.

The specimens of this, the smallest and at the same time most abundant of the Wasatch species, were referred by Cope to *H. vicarius* and *H. paulus*, both of the Bridger horizon. Osborn* provisionally referred them to *H. miticulus* Cope, from the New Mexico Wasatch, but differing from *H. simplex* in being somewhat larger and having a low ("Esthyonyx-like") heel and in having the posterior cusps more developed.

For a type, a lower jaw of the left side carrying the fourth premolar and the molars is chosen. All the teeth of the lower jaw are short and wide with obtuse cusps. On each there is a trace of a cingulum about the rounded anterior outer corner of the tooth and also externally between the cusps. On the wide fourth premolar the protoconid is better developed than the deuteroconid, and behind there is a wide basin, the posterior margin of which is crenulated. On molars one and two the protolophid is well developed, while there is not more than a trace of a metalophid. A strong ridge runs from the hypoconid to the metaconid. The entoconid is weak and has a small tubercle in front of it, very characteristic of the species. On the last molar the heel region consists of a basin bounded behind by a high crenulated rim, on which the hypoconulid and entoconid appear as crenulations, scarcely larger than the others.

FIG. 2. *Hyopsodus simplex.* Left ramus. ×$\frac{3}{1}$.

Each of the upper molars has the cingulum in front, outside and behind. The last of these molars is much reduced and is without a true hypocone. Promolars three and four have each an internal cusp, while the front two are simply cusps.

Affinities—*H. simplex* is about the same size as *H. vicarius* from the Bridger, but the molars are shorter and more robust, while the hypoconulid is less developed and has an extra tubercle in front of it. *H. paulus* is a much larger and better developed species. *H. miticulus* is the nearest form, the more specialized and low talonid, and the superior size distinguishing it from *H. simplex.*

* Bull. Amer. Museum Nat. Hist., xvi, 183, 1902.

Locality—27 specimens were collected from both the upper and lower beds of the Wasatch on Gray Bull River.

They run very uniform in size, the length of the three lower molars being between 10 and 11^{mm}. In a few cases the last lower molar was considerable smaller than the normal.

Hyopsodus miticulus Cope.*

This form from the New Mexico Wasatch is thus described by Cope: "Parts of several specimens of this species show that the molars are similar in size to *H. paulus*, but that it has a much smaller last inferior molar, which has such a low heel as to resemble the corresponding tooth of the species of *Esthonyx*."

The species seems to resemble *H. simplex* most, but is larger and differs in the heel being low, and more developed. The last molar is also proportionally smaller. The two cannot in the writer's opinion be included in one species.

Hyopsodus lemoinianus Cope.†

This species presents several difficulties on account of the large amount of variation in size, and in the development of both the metaconid and the metalophid; but in as much as these variations do not seem to be constant, and as intermediate forms are found between the widest variations, all these related forms have been assigned to the one species. *H. lemoinianus* was established by Cope, who figured a left ramus with the molars, on which the metaconid is but slightly bifid. Osborn figures a second specimen with the metaconids also but little twinned. Most of the Amherst specimens have this cusp markedly bifid, as is seen in the specimen figured.

FIG. 3. *Hyopsodus lemoinianus.* $\times \frac{3}{1}$.

The species may be described as follows: There is a cingulum on the front of the tooth, and between the external cusps of the moderately stout teeth. On molars one and two, there is developed on the inner end of the protolophid a small but distinct paraconid, which makes the metaconid appear bifid. The metalophid is either entirely wanting or but moderately developed. The entoconid is small, as is also the hypoconulid. The last lower molar is longer, and similar except that the hypoconulid is developed into a prominent heel. On the upper molars the cingulum is well marked and the cusps fairly high.

The three lower molars measure 13 to 15^{mm}, there being considerable variation in size. The nine specimens collected all occurred in the basal beds along the Gray Bull River, Wyoming.

* Rep. Vert. Fossils of New Mexico, Appen. F.F., Rep. Chief. Eng., 8, 1874.
† Proc. Amer. Phil. Soc., xx, 148, 1881.

Hyopsodus powellianus Cope.*

This, the largest species of the *Hyopsodidæ*, occurs but infrequently, being known by parts of the lower jaw only. The teeth are low and wide with stout, low cusps and no cingulum. The metaconid is simple and widely separated from the protoconid. The hypoconulid is small, even on the last molar. The protolophid is low and the metalophid lacking. On the last molar the entoconid region is occupied by two small cusps.

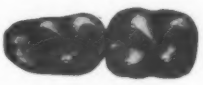


FIG. 4. *Hyopsodus powellianus.* ×⅔.

The three lower molars measure together 18mm. In the Amherst collection the species occurs but twice, both specimens coming from the basal beds of the Wasatch of the Gray Bull River, Wyoming.

Hyopsodus laticuneus Cope.†

A single specimen represents this species, on which the genus *Diacodexis* also hangs. The specimen included both upper and lower teeth, but Matthew has removed the lower premolars and assigned them to *Eohippus index*, leaving the upper molars which are characteristic of the genus *Hyopsodus*, and a last lower molar which is distinguished by low broad crown with obtuse cusps, lack of an external cingulum and the entoconid region occupied by two small cusps, and lastly by the metaconid being bifid. This last character alone distinguishes the species from *H. powellianus* to which it is equal in size. The specimen came from the Wasatch in the neighborhood of Gray Bull River.

In the Wind River horizon, four species are known, three of which are here described for the first time. This horizon is marked by a slight advance in the development of the genus. The hypoconulid is stronger, especially on the last molar, and in the entoconid region there is only a single strong cusp, the entoconid. The metalophid is universally present.

In the locality found by the Amherst party the specimens of *Hyopsodus* formed fully a third of the collection.

Hyopsodus wortmani Osborn.‡

The type specimen (including an upper and a lower jaw) was first figured by Cope among *H. vicarius* specimens, and was later by Osborn removed and used as the type of this species, the description however being very meager.

The teeth are moderately wide with rather low cusps and a cingulum along the front only. On the fourth premolar the protoconid and deuteroconid are connected by a sharp ridge; the basin behind is wide, and on the outer side of the rim is a

* Rep. U. S. Geol. Surv., iii, 235, 1884.
† Proc. Amer. Phil. Soc., xx, 181, 1881.
‡ Bull. Amer. Museum Nat. Hist., xvi, 185, 1902.

small cusp. The protolophid and metalophid are both well developed on the first and second molars but on molar three the latter is very weak. The hypoconulid is small on the first two molars but developed into a prominent heel on the last, the entoconid being tiny. The upper molars are those typical of the genus, having a cingulum in front, outside and behind.

FIG. 5. *Hyopsodus wortmani.* ×$\frac{3}{1}$.

The specimens run uniform in size, the three inferior molars measuring 12^{mm}. On Bridger Cr., 37 specimens were collected and the species occurs also in the other Wind River localities.

Hyopsodus minor sp. nov.

Though but one example of this tiny form was found, it differs so materially from *H. wortmani* that it is impossible to include it in that species. The type specimen is part of the right ramus with the three molars measuring together 10^{mm}.

The teeth are short, with obtuse but well-separated cusps, and have a cingulum in front and a trace of it between the external cusps. The proto- and meta-conids are set close together and united by both a protolophid and metalophid. The hypoconid has a strong ridge running to the metaconid, while the hypoconulid and entoconid are both strongly developed.

FIG. 6. *Hyopsodus minor.* ×$\frac{3}{1}$.

The species is distinguished by its small size, presence of a cingulum externally and the strength of the ento- and hypoconulid. The locality is Bridger Cr., Wyoming, in the Wind River horizon.

Hyopsodus browni sp. nov.

This, the most abundant species in the Wind River beds, is named in recognition of the successful work of Mr. T. C. Brown in collecting these forms. The type is a left ramus with the molars and fourth premolar; while an upper jaw with premolars three and four is associated with it as co-type. A less complete specimen has both upper and lower dentition.

The teeth of the lower jaw are short and stout with obtuse cusps, and a cingulum along the front only. On the fourth premolar the deuteroconid is merely indicated by a small cusp, and behind on the proterior margin of the basin, there is a small external cusp. On all the molars the proto- and meta-conids are set close together and united by both a proto- and meta-lophid. The hypoconid is large and connected the meta-conid by a wide ridge. The hypoconulid is rather large on all the molars but does not make a strong heel on the third molar.

The upper molars have a cingulum in front, outside and behind; on the which, where it meets the ridge from the para-

cone, there is a strong parastyle. The protoconule is closely united to the protocone. The last molar is large, but still lacks the hypocone. The third and fourth premolars have the parastyle but lack the intermediates and hypocone.

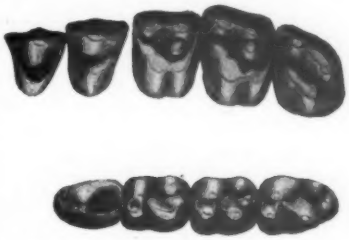


FIG. 7. *Hyopsodus browni.* × 4.

The species includes the medium sized individuals of the Wind River, the three lower molars measuring 15mm. It compares in size to *H. lemoinianus* but lacks the external cingulum, and has a simple metaconid as well as having much more obtuse cusps. There are 45 specimens in the Amherst collection all from Bridger Cr., Wyoming.

Hyopsodus jacksoni sp. nov.

In many ways this is the most specialized of the *Hyopsodidæ*, and it has been named in recognition of the interest and coöperation of Mr. E. E. Jackson in the Amherst expeditions. The type is a right ramus with the molars and the fourth premolar, and a third premolar from the left side. The co-type contains three upper molars.

FIG. 8. *Hyopsodus lawsoni.* × 4.

The lower molars are rather narrow with moderately high cusps and a cingulum along the front side only. The metaconid is bifid, strongly so on the first molar, and just visibly so on the last. The protoconid and metaconid are widely separated and connected by the protolophid only. The hypoconulid is throughout small; and on the third molar connected by a ridge to the entoconid. The fourth premolar is complex, the protoconid and deuteroconid being connected by a ridge; and there are two well-developed cusps behind on the posterior rim. The third premolar is similar but lacks the two posterior cusps. The upper molars are those typical of the genus, with the cingulum well developed on the outside. A distinct parastyle is formed on the anterior external angle of the cingulum. The posterior intermediate is isolated while the anterior one is connected to the protocone.

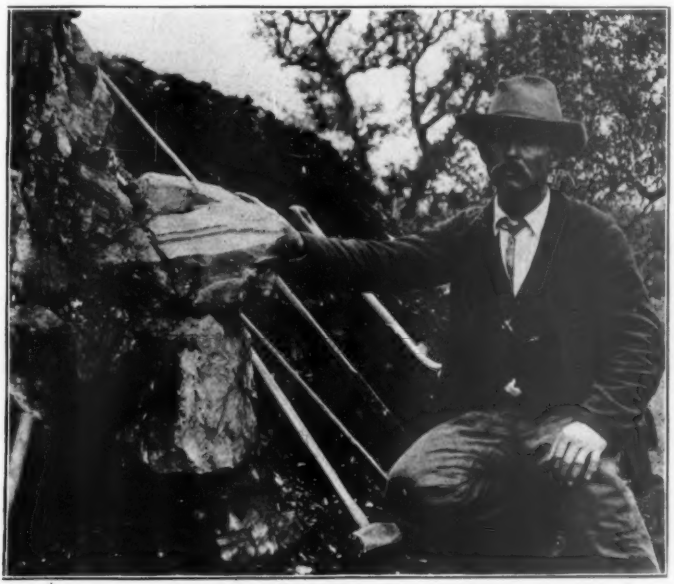
The three lower molars measure together 16mm. 26 specimens were found along Bridger Cr., Wyoming.

	H. simplex.	H. miticulus.	H. lemoinianus.	H. powellianus.	H. laticuneus.	H. wortmani.	H. minor.	H. browni.	H. lawsoni.
Lower premolar 4	Deuteroconid strong: posterior margin of basin crenulated without cusps		Deuteroconid strong and bifid: posterior margin of basin with two tiny cusps			Deuteroconid smaller than protoconid: connected by ridge: posterior margin with external cusp		Deuteroconid very small: posterior margin with external cusps	Deuteroconid connected to protoconid by ridge: posterior margin with two cusps
Lower molars 1 & 2	External cingulum, traces: hypoconulid large: no metalophid: entoconid with tubercle in front: metaconid simple	No external cingulum: hypoconulid medium: no metalophid: entoconid simple: metaconid simple	External cingulum, traces: hypoconulid strong: no metalophid: entoconid medium simple: metaconid bifid	No external cingulum: hypoconulid small: no metalophid: entoconid small: metaconid simple		No external cingulum: hypoconulid small: metalophid: entoconid small: cusps alternating: metaconid simple	No external cingulum: hypoconulid large: metalophid: entoconid medium: metaconid simple	No external cingulum: hypoconulid large: metalophid: entoconid medium: cusps alternating: metaconid simple	No external cingulum: hypoconulid small: metalophid weak: entoconid small: metaconid bifid
Lower molar 3	External cingulum, traces: metaconid simple: entoconid one of several small tubercles: heel not prominent	No external cingulum: metaconid simple: entoconid with a small tubercle in front of it; heel fairly prominent	External singulum, traces: metaconid bifid: entoconid with small tubercle in front: heel prominent	No external cingulum: metaconid simple: entoconid with large tubercle in front of it: heel not prominent	No external cingulum: metaconid bifid: entoconid with small tubercle in front of it: heel fairly prominent	No external cingulum: metaconid simple: entoconid with small tubercle in front of it: heel prominent	No external cingulum: metaconid simple: entoconid simple: heel prominent	No external cingulum: metaconid simple: entoconid simple: heel medium	No external cingulum: metaconid slightly bifid: entoconid simple: heel prominent
Length of 3 lower molars	10–11 mm	12 mm	13–15 mm	18 mm	About 18 mm	12 mm	10 mm	15 mm	16 mm
Horizon	Wasatch	Wasatch (New Mexico)	Wasatch	Wasatch	Wasatch	Wind River	Wind River	Wind River	Wind River
No. of specimens	27	0	9	2	0	37	1	45	26

Art. XLV.—*Some Results of late Mineral Research in Llano County, Texas;* by William E. Hidden.

The noted gadolinite locality in Llano County, Texas, known as Barringer-Hill, was reopened* and thoroughly prospected by the writer, during the winter of 1902–03, with very encouraging results. All the old cuts were cleaned out and extended, and a systematic development of the mine was begun at the southeast point of the hill, and at as low a level as the river terrace would permit. The plan was to remove the hill by blasting and gradually make a dump of

1



73-lb. mass of Gadolinite in place.

it towards the near-by Colorado river. The season proved to be a very propitious one and much good work was accomplished. Seven years had elapsed since any work had been done upon the property, but in a short time all the old familiar minerals had been rediscovered either in new openings or in extensions of the original workings of Mr. Barringer.

* The development was undertaken under the auspices of the Nernst Lamp Company, of Pittsburgh, Pa., to whom all the output was sent.

Among the most notable discoveries of "Barringer-Hill" minerals, at this time, were the double crystal of gadolinite that weighed seventy-three pounds and an eighteen-pound mass of yttrialite (see figures 1, 2 and 3); a mass of pure allanite that weighed over three hundred pounds; about fifty pounds of thoro-gummite, among which were pieces weighing fully a pound and some few good crystals. Of fergusonite several very pure masses and large aggregations of rough crystals were found, up to five pounds in weight. Of rowlandite one very pure mass weighing just one kilo was obtained; of nivenite and mackintoshite very little was discovered. The mineral

2

species rich in yttrium-erbium were more particularly sought after because thorium and uranium were not used in the "glower" of the Nernst Lamp.

Masses of coarsely crystallized fluorite up to four hundred pounds weight were not rare, and some of these had very large faces of the cube and rhombic dodecahedron. Its color varied from dark green to puce and purple, and colorless transparent rough crystals having remarkably perfect cleavage were sometimes observed. Some of the fluorite was true chlorophane and exhibited a brilliant green light when strongly heated and viewed in the dark. One mass was self-luminous, at night,

without heating it. Enormous crystals of orthoclase were common, some over five feet in diameter. Quite frequently small veins of very perfect red feldspar crystals (highly-twinned), and upon which albite crystals were attached, were found bordering the fluorite and penetrating it. In the feldspar, well crystallized menaccanite was sometimes observed, and this mineral is new to the locality. Yellow rutile, of the sagenitic variety, was observed in only one instance and then upon smoky quartz crystals. Polycrase, or an allied species,

3

18-lb. mass of Yttrialite.

was seen implanted upon the gadolinite, this is also new to the region. A cavity into which a horse could have been put was discovered on the river side of the mine, and from it a large crystal of smoky quartz was taken that weighed over six hundred pounds. It was forty-three inches high and twenty-eight inches broad and fifteen inches thick. This is now in the University of Texas collection at Austin, Texas.

Very fair amethysts were found in the west end of the hill, in cavities in the feldspar. Masses of biotite, four feet across,

were met with and always indicated the presence near-by of the rare-earth minerals. Some of the fluorite contained small thin veins of a very dark mineral, which was deep indigo-purple by transmitted light, and this may, perhaps, betoken the occurrence of a basic fluoride of the yttrium or cerium earths at this mine and in the region generally.

In a period of four months there was taken out of the hill enough of the yttrium ores to suffice for the Company's needs for the balance of the year, and the mine was therefore closed for the season.

In the following winter (1903–4) the work was again resumed at Barringer-Hill, and about a dozen workmen were kept constantly employed for a period of six months. The scheme of development laid down by the writer in 1902, was carried forward with much energy. Considerable "dead-work" was done in the line of removing "topping" and bringing up the "fall" from the river-side of the hill. New cuts were opened, and the whole top of the hill was blasted away. All the work done at the mine thus far has been of the character of open quarry work, with hand-drilling and the use of powder and dynamite. The mine has been proved to have a deep-seated origin and is only one of a series of so-called "blow-outs" in a region that is entirely granitic. Deep work at this locality may be expected to bring to light new combinations of the rare earths and of uranium and of thorium, as well as great quantities of the species for which the hill is already famous. All the old species will probably be found in a purer state and perhaps in their normal condition as when first crystallized. This last mentioned condition is what we are eagerly seeking for in order to clear up the formulae of many of the species.

During last winter's work all the old minerals, excepting rowlandite, were again found and more than one thousand pounds of very pure gadolinite. The seventy-three pound group of crystals (of gadolinite), found in March, 1903, was the greatest "find" of record in this mineral; but just one year later, a mass of roughly crystallized gadolinite was found, partly imbedded in the bed-rock at the northeast corner of the hill, that measured thirty-six inches long, eleven inches thick at the widest part, and weighed a little over two hundred pounds. It was apparently free from alteration, had specific gravity of 4·28 (taken on a very pure fragment), had a bright green chatoyancy at certain angles, and was like glass in its broad obsidian-like conchoidal fracture.

Upwards of a pound of very pure nivenite and not exceeding an ounce of mackintoshite, were picked out of the many boxes of mixed cyrtolite, fergusonite and thoro-gummite.

Only the density of nivenite saved it from being thrown away as magnetite (very abundant at this mine), and but for its associations it would be always neglected except by the expert mineralogist. Equally so with the mackintoshite, its resemblance to the dark cyrtolite and intimate association with it, prevents it from being recognized by the miner or layman. Some day this mine promises to be worked for the two last-named minerals alone and as the main object of mining there, and in the deeper working they should be found abundantly and in a higher state of purity.

Tengerite (?)—About ten grams of a white mineral, occurring in semi-globular and flat radiated concretions in the cracks and fissures of the gadolinite, were finally obtained after much labor and search. This quantity was the result of detaching the mineral, bit by bit, from over 300 kilos. of fresh gadolinite. Since the composition of tengerite (to which species this substance is tentatively referred) is unknown, I submitted the rare mineral to Dr. W. F. Hillebrand of the U. S. Geol. Survey for analysis; his report is given in full below. The surprising feature is the presence of glucina (BeO) in the form of carbonate, which is new to science, and this may perhaps indicate a new glucinum mineral mechanically mixed with a basic hydrous carbonate of the rare earths of the yttrium group.

Dr. Hillebrand's Report and Analysis.

"The purest material that could be picked out, from that at my disposal, showed some brown admixture with the white. The following results were obtained from ·3640 gram of this selected material, after deducting ·0262 gram of residue, left after long treatment of the ignited powder with cold and quite dilute nitric acid.

Y_2O_3 group	40·8	per cent	Mol. wt. 226
Ce_2O_3 group	7·0	"	" " 335
Fe_2O_3	4·0	"	
BeO (GlO)	9·7	"	
CO_2	19·6	"	
H_2O above 105°	14·1	"	
H_2O below 105°	3·2	"	
SiO_2	·4	"	
MgO, Alk., loss	1·2	"	
	100·0	"	

All determinations were made on the one portion, the CO_2 and H_2O being directly and simultaneously ascertained by ignition in a tube and collection of the escaping gases. The loss in weight

of the ignited powder agreed with the sum of the CO_2 and H_2O found. Approximate molecular weight determinations of the earths, separated into two portions by potassium sulphate, gave 335 for the cerium group and 226 for the yttrium group, the last being the molecular weight of yttria itself. It is certain that some, if not all, of the ferric oxide reported is foreign to the carbonate, but how much it is impossible to say. The calculated ratios lead to nothing definite, except that the white mineral appears to be a hydrous basic carbonate, but whether a double carbonate of the rare earth metals and glucina, or a mixture, there are no present means of deciding."

Radio-activity.—All the minerals of Barringer-Hill have been experimented with to ascertain the extent of this form of energy present. As early as September, 1902, the writer was at work upon it and had then made successful radiographs from specimens mined at this locality as far back as 1889. In the order of their activity, as shown by their own radiographs, I here mention the species in which the phenomena were observed.

Nivenite (which is a very soluble variety of uraninite) exhibited the most pronounced radio-activity, and beautiful radiographs were made by placing the mineral outside of a photograph plate-holder. Better ones were procured by placing the mineral in direct contact with the sensitive plate—"Cramer's X-ray." Twelve hours exposure, in the dark, developed very good interference figures; but with forty-eight hours, and up to five days exposure, the outlines became as sharp almost as are shown in photographs by sunlight.

Mackintoshite (which is the parent mineral of thoro-gummite) was next in the amount of radio-activity exhibited. It showed about half the intensity of nivenite when compared with equal exposures of the two minerals, side by side, on the same plate.

Positive evidence of the occurrence, within mackintoshite, of little crystals having even a *higher radio-activity* than that shown by the nivenite, was proven by developing the plates used with direct contact. Little bright spots appeared in the field where the less energetic mackintoshite had touched it, and a dull gray border (made by the thoro-gummite coating) united to make a radiograph having *three* degrees of intensity from one mineral specimen. With a strong lens these bright spots, possibly due to a new species, could be identified upon the flattened surface and they were noticed to be very unlike the surrounding mackintoshite. They resembled galena in color and in metallic luster and were quite evenly distributed over the several flat sections examined. Mackintoshite has given evidence, in thin sections, of being translucent, and of a very dull green color by transmitted light, but as the purest

material yet analyzed showed (vide Hillebrand's analysis) 4·31 H_2O present, it is possible that these little bright spots are only the normally pure anhydrous mineral. It is tenable also that these little inclusions, with their high radio-activity, are but a normally pure form of nivenite in which only UO_2 is present. Since mackintoshite can be rationally interpreted as being a mixture of three parts of thorite with one of uraninite (nivenite), the assumption that a new mineral has been discovered may not stand. The question is certainly one of unusual interest at this time and merits further investigation.

Thoro-gummite.—Contact radiographs of this mineral, made from a flattened surface after forty-eight hours exposure, *in the dark*, had much the appearance of ordinary sunlight photographs. All the minute details of structure and varying degrees of radio-activity were beautifully portrayed. It was surprising to note how perfect a picture this mineral could make of itself without any outside aid other than a photographic plate and a long exposure in the dark.

Masses up to a pound weight were found, and this proves that mackintoshite will not be as rare as it is now, when the mine is worked down to lower levels; for thoro-gummite is only an alteration product of mackintoshite, it having assumed one more molecule of water and changed its UO_2 to UO_3, and its color from an apparent jet-black mineral, of specific gravity 5·50, to a dull yellow-brown mineral having specific gravity 4·54+. Long square prisms, like those of zircon, with simple terminal pyramidal planes, were observed.

Yttrialite.—This species gave better radiographs from its altered red crust and its yellow ochreous variety than from the pure dark gray-green anhydrous mineral. All of its radio-activity must emanate from the ten to twelve per cent of thoria present. Hillebrand's last analysis has shown that its composition can best be interpreted by assuming that it is a mixture of an yttrium silicate with the thorite molecule (both anhydrous). Slabs of this mineral eight inches long and six inches broad were broken from some of the larger masses, thus affording fine opportunity for large experimentation in testing it radiographically.

Fergusonite.—The mono-hydrated variety made the best radiographs, but all the varieties (of which there are four at the locality) showed more or less action upon the sensitive film.

A new association was discovered in this species. Symmetrically compounded crystals of nivenite with fergusonite were found in the south walling of the hill. Long square prisms of nivenite with flat terminations, had in their centers an equally long but tapering pyramidal crystal of fergusonite, in parallel position. Some of these were one inch long and one-quarter

inch thick. The fergusonite was of the purest kind and almost transparent, and somewhat resembled the famous Spanish sphalerite.

Cyrtolite.—Many hundred pounds were found and in great variety of form and color. All kinds of it gave good radiographs after twenty-four hours exposure. Plates of it as large as one's hand, covered on one side with curved crystals, were not rare. It sometimes encrusted large quartz crystals to the depth of one inch, having radiate structure, and thus afforded a new feature for this mineral and one very uncharacteristic of zircon.

4

Radial Lines from the Ore Masses.—As early as December of 1902, my attention was attracted to the strange occurrence of unusually long radial lines projecting in many directions from the bodies of ore richest in thorium, uranium and zirconium. I then named these occurrences "stars" and eagerly sought for them, as positive "pointers" to ore. At last I was obliged to give these "stars" more than passing attention and here state the reason: While removing, piece by piece, a seventy-pound mass of mixed zirconium-yttrium-uranium and thorium ore, which was a nucleus to one of the best marked of these "stars" (see fig. 4) from its quartz matrix, my hands and face would begin to burn as if from the effect of strong

sunlight, and after two or three days of this kind of mining a redness of skin and a burning sensation would be followed by actual soreness of the parts of my hands and face exposed to the direct emanations from the minerals. My assistant (Mr. J. Edward Turner) complained of it also, and asked me "if these minerals could be poisonous?" As no arsenic was present, the soreness which we both experienced might possibly have been caused by free fluorine, but not by any soluble constituent of the mineral, since salts, such as would be dissolved by the moist skin, had long ago been dissolved, leached out and redeposited in the "chimney" of the mine. It was some time after this that the thought came to me that this action might be the work of a radio-active element and it is offered now more as a suggestion than as a proven fact. I incline strongly to the idea, however, of my having actually experienced the proof of the presence of a very high degree of radio-activity, of a peculiar if not unique kind, at this mine, and that the symptoms above described go a long way towards proving it. Of the true nature of this activity I will not at this time offer any conjectures, but will defer a discussion of it to a paper which is under preparation relating to this very interesting region.

Many photographic records were taken of these "stars," and one of them is shown in fig. 4; they are sometimes eight or ten feet across. Although these radial lines are not new to science, having often been noted elsewhere in connection with allanite, monazite and other rare species, it is not likely that they have been before observed on so large a scale. The cause of this phenomenon has not been determined, so far as I am informed, but it is not without interest that these radial lines are noted only with certain minerals containing rare elements and are most conspicuous with the radio-active species.

Art. XLVI.—*A New Allotrope of Carbon and its Heat of Combustion;* by W. G. Mixter.

[Contributions from the Sheffield Laboratory of Yale University.]

The investigation of the carbon which separates when acetylene under pressure is exploded forms a part of the study of the thermal constants of the gas. The heat of formation of acetylene according to Thomsen is 47,700 calories; Berthelot's figures are 51,400 calories, and the writer by a direct determination obtained 53,300 calories for the heat of dissociation.* As these results vary so much it appeared desirable to investigate the thermal constants of the constituents of acetylene. The work on hydrogen has been published.† The writer concluded from the study of acetylene that the carbon from it would give a different heat of combustion from that of other forms of carbon. The results obtained confirm this view and indicate that acetylene carbon is a distinct allotropic form. The thermal effect of burning 12 grams of different kinds of carbon found by Favre and Silbermann, Berthelot, and the writer is as follows:

Wood charcoal.	Sugar charcoal.	Gas retort carbon.	Graphite.	Diamond.	
96,960^c	96,500^c	96,568^c	93,559^c	93,240^c	Favre & Silbermann
97,650^c			94,810^c	94,310^c	Berthelot
	96,700^c		94,000^c		M.

Acetylene carbon ..... 94,728^c

The figures show that the carbon from acetylene is very different from the amorphous varieties of the charcoal type, and that its heat of combustion is nearly the same as that of graphite. Moissan has shown that it is not graphite, and does not contain graphite, as it does not yield graphitic acid on treatment with a mixture of potassium chlorate and fuming nitric acid, and my own test gave the same conclusive result.

The acetylene carbon as it comes from the bomb is a greyish black, lusterless and very bulky, porous mass. When compressed it has a brilliant black luster, but not the metallic appearance of graphite. It is a good conductor of heat and electricity. While one gram condenses one milligram of dry air on its surface and in the pores, it does not exert catalytic action on the gases of decay in presence of air, such as we are familiar with in case of charcoal. When a mixture of acetylene carbon and sulphuric acid is boiled no odor of sulphur dioxide is perceptible, but the escaping vapors turn a blue

* This Journal, xii, 347. † This Journal, xvi, 214.

iodide of starch paper white. Dense sugar charcoal decomposes the hot acid readily.. Acetylene carbon absorbs only about, 1/10 of 1 per cent of its weight of moisture from the air, differing in this respect from charcoal. The determination of density was made as follows: The carbon of the second series of experiments was placed in absolute alcohol, which was then boiled to expel air; ethylene bromide was next added and the boiling repeated. By successive additions of alcohol and bromide a liquid was obtained in which the carbon remained suspended over night. Professor Penfield kindly determined on a Westphal balance the density of this liquid and found it to be 1·919 at common temperature.

First Series of Experiments.

The bomb used for this part of the work was the one described in this Journal, xii, 347, but with the addition of a long narrow neck. Two determinations of the water equivalent of the calorimeter at 20° gave 285 and 281·2 grams and the equivalent calculated from the specific heats of the metals was 284·7 grams. Since the fittings of the calorimeter varied somewhat in the different experiments, the figures for the water equivalent vary slightly. The carbon in a loose bulky mass in the bottom of the bomb was ignited by the glowing magnetic oxide which dropped into it when the iron wire attached to the platinum electrodes was ignited by an electric current. The combustion was explosive in character and complete, and gave a temperature that fused the ends of the thick platinum wires. The thermometer would rise perceptibly in three seconds after passing the electric current. The oxygen used was made from potassium chlorate and collected in a glass gas holder over a dilute solution of potassium hydroxide. In order to have the bomb fairly free from nitrogen it was repeatedly exhausted and filled with oxygen and then the gas was pumped in until the pressure was between 10 and 15 atmospheres. The weight of the oxygen was found by weighing the bomb before and after filling it with the gas.

In the first three experiments the silver plating protected the steel from oxidation, and the silver dissolved by the nitric acid formed was not determined. For the remaining tests the bomb was lined with a tight fitting shell of silver 1^{mm} in thickness, and the silver dissolved was precipitated and weighed as chloride. The heat of burning 1 mlg. of iron was considered to be 1·6 calory.

The air condensed on the surface of the carbon in the loose form in which it was weighed for the various experiments was found as follows:

A cylindrical glass vessel with a long neck and stopcock and having a capacity of 67^{cc} was filled with 3 grams of acetylene carbon. It was exhausted and heated for an hour to about 400° and then allowed to cool and the stopcock closed, the mercury pump being in action all the time. Next it was counterpoised by a similar vessel and the needed weights, and finally dry air was admitted and the increase in weight observed. The data required are the weight and density of the carbon, the capacity of the vessel, the weight of the air admitted, the temperature and barometric pressure. The results of three determinations were 3·2, 3·4, and 3·1 milligrams of air condensed by 3 grams of the carbon. The apparatus was crude and the result is to be regarded merely as proving that but little air is condensed by the carbon.

The carbon for the first series of tests was from the sample obtained three years ago in the determination of the heat of dissociation of acetylene.* It contained a little incombustible matter or ash derived from the bomb and the impurities of the gas from which it was made. The composition of it was found as follows: The carbon was compressed in a large platinum tray open at one end and nearly closed on top and the tray and contents were placed in a long narrow platinum crucible with a close-fitting cover and heated to redness. After cooling over sulphuric acid the whole was weighed, then heated again, allowed to cool as before and then the weight was quickly taken. With these precautions the error due to moisture is negligible. The observed weight was corrected for ash, absorbed air and reduced to weight in vacuum. The combustion was made with oxygen and oxide of copper. The water was absorbed in a U-tube filled with beads drenched with sulphuric acid and the carbon dioxide by a solution of potassium hydroxide in a helical tube, the unabsorbed gas passing through a U-tube filled with solid potassium hydroxide and then through another tube containing beads drenched with sulphuric acid. To the last tube there was an attachment to keep out moisture. Each piece of absorption apparatus was counterpoised on the balance by a similar one to eliminate the effects of atmospheric changes. For each gram of carbon dioxide 0·5 of a milligram was added for reduction to weight in vacuum. This was the correction calculated for the solution of potassium hydroxide used which had a density of 1·38; it was also found by experiment to be the same. The calculations are based on the atomic weights 12 and 16 of carbon and oxygen respectively. The following are the results:

* Loc. cit.

	I.	II.	Mean.
Acetylene carbon taken..	1·1485	1·3838 gram	
Carbon	99·93	99·96	99·95 per cent
Hydrogen.....	0·04	0·03	0·03 "

The weight of the substance, corrected as already described, multiplied by 0·9995 was taken to be the amount of carbon burned in the calorimeter. The specific heat of both oxygen and carbon dioxide at constant volume is very nearly 0·15. Hence the product of this number by the total weight of the carbon and oxygen is included in the water equivalent of the calorimetric system. The observed weight of the water in the calorimeter was reduced to weight in vacuum. The temperature observed the instant before an explosion was taken as the initial temperature and it was assumed that the gain and loss of heat were equal during the first minute after an explosion, and correction was made for the loss during the four minutes following. Thermometer No. 172863, described in the paper on "The Heat of Combustion of Hydrogen,"* was used in this first series of experiments.

Experiment 1.—Carbon 1·3740, hydrogen 0·0004, iron 0·070, oxygen 10·2 grams.

Water.....	2190· grams
Water equivalent of calorimeter.	258·6 "
" " carbon dioxide and oxygen	1·7 "
	2450·3 "

Minutes.	Temperature.	Temperature interval.
0	18·700	
1	18·700	23·124 − 18·7 + 0·04 = 4·464°
2	22·5	
3	23·115	Heat observed, 2450·3 × 4·464 = 10938c
4	23·139	" of oxidation of iron −112c
5	23·133	" " " hydrogen − 14c
6	23·124	
7	23·113	10812c
8	23·102	
9	23·092	For 1 gram of carbon 7869c

The water with which the bomb was washed after the experiment was free from silver.

Experiment 2.—Carbon 1·0318, hydrogen 0·0003, iron 0·030, oxygen 10·5, water and water equivalent 2543·4 grams.

* This Journal, xvi, 214.

Minutes.	Temperature.	Temperature interval.
0	18·426	
1	18·430	21·669 − 18·442 + 0·009 = 3·236°
2	18·434	
3	18·437	Heat observed, 2543·4 × 3·236 = 8230·6c
4	18·442	" of oxidation of iron −48· c
5	21·4	" " " hydrogen −10·2c
6	21·672	
7	21·672	8172·4c
8	21·672	For 1 gram of carbon 7919·5c
9	21·669	
10	21·666	The slight amount of silver dissolved
11	21·664	was not determined.
12	21·661	
13	21·659	
14	21·657	

Experiment 3.—Carbon 1·1136, hydrogen 0·0003, iron 0·030, oxygen 10·5, water and water equivalent 2599·6 grams.

Minutes.	Temperature.	Temperature interval.
0	18·843	
1	18·845	22·230 − 18·851 + 0·02 = 3·399°
2	18·847	
3	18·849	Heat observed, 2599·6 × 3·399 8836·1c
4	18·851	" of oxidation of iron −48· c
5	21·95	" " " hydrogen −11· c
6	22·231	
7	22·238	8777·1c
8	22·235	For 1 gram of carbon 7881·7c
9	22·230	
10	22·226	
11	22·221	
12	22·216	

In the next three experiments a larger german silver calorimeter can was used and the bomb was lined with pure silver as already described.

Experiment 4.—Carbon 1·2688, hydrogen 0·0004, iron 0·050, oxygen 10, water and water equivalent 3434·8 grams.

Minutes.	Temperature.	Temperature interval.
0	18·381	21·315 − 18·381 + 0·018 = 2·952°
1	18·381	
2	18·381	Heat observed, 3434·8 × 2·952 = 10139·6c
6	21·309	" of oxidation of iron −80· c
7	21·315	" " " hydrogen −13·6c
8	21·312	" of formation of silver nitrate −18·4c
9	21·307	
10	21·302	10027·6c
11	21·297	For 1 gram of carbon 7903·4c
12	21·292	

According to Thomsen* the thermal effect of the formation from its elements of $Ag_2N_2O_6$ and solution in water is 46,600 calories. From which we find that 1 mlg. of silver dissolved corresponds to 0·216°. The solution from the interior of the bomb after an explosion in no instance reacted acid to ordinary litmus paper, showing that the nitric acid was mostly taken up by the silver. In experiment 4, 85·4 mlgs. of silver were found in rinsings, showing 18·4° were due to the oxidation of nitrogen and solution of silver.

Experiment 5.—Carbon 1·3054, hydrogen 0·0004, iron 0·0385, silver dissolved 0·0726, oxygen 10·2, water and water equivalent 3302·2 grams.

Minutes.	Temperature.	Temperature interval.	
0	18·958		
1	18·958	22·083 − 18·958 + 0·021 = 3·146°	
2	18·958		
3	21·8	Heat observed, 3302·2 × 3·146 =	10388·7°
4	22·079	" of oxidation of iron	−61·6°
5	22·092	" " hydrogen	−13·6°
6	22·088	" formation of silver nitrate	−15·7°
7	22·083		
8	23·077		10297·8°
9	22·073	For 1 gram of carbon	7888·8°
10	22·067		
11	22·062		
12	22·055		
13	22·051		

Experiment 6.—Carbon 1·3277, hydrogen 0·0004, iron 0·040, silver dissolved 0·0918, oxygen 9·7, water and water equivalent 3253·9 grams.

Minutes.	Temperature.	Temperature interval.	
0	18·894		
1	18·896	22·135 − 18·9 + 0·014 = 3·249°	
2	18·898		
3	18·900	Heat observed, 3253·9 × 3·249 =	10572·°
4	21·9	" of oxidation of iron	− 64·°
5	22·129	" " " hydrogen	− 13·6°
6	22·139	" formation of silver nitrate	− 19·8°
7	22·137		
8	22·135		10474·6°
9	22·131	For 1 gram of carbon	7889·4°
10	22·127	The gas in the bomb after the calori-	
11	22·124	metric test was transferred to a gas	
12	22·121	holder containing a solution of caustic	
13	22·117	potash and was left several hours to	
14	22·114	ensure the complete absorption of car-	
15	22·111	bon dioxide. It was then passed into	
16	22·108	a solution of barium hydroxide and	

* Thermo-Chem. Untersuchen, iii, p. 282.

over glowing copper oxide, and finally through a clear solution of barium hydroxide. The barium solutions remained clear. In the delivery tube in the second there was a faint white ring indicating that the gas contained a trace of carbonic oxide. The same result was obtained in subsequent experiments and is what might be expected in a cooling mixture of oxygen, carbon dioxide and carbonic oxide formed directly from the burning of the carbon and by the dissociation of carbon dioxide by heat. The amount of carbonic oxide remaining in the bomb was, however, too small to be estimated by ordinary methods or to have an appreciable influence on the thermal result.

The mean of the foregoing results is 7892· calories for one gram of carbon. This is considerably less than other investigators found for amorphous carbon and not much higher than obtained for graphite. In order to find if the variation was due to a constant error, sugar charcoal and graphite were burned in the apparatus used for experiments 4, 5 and 6.

Sugar Charcoal.

The charcoal was prepared by charring sugar and heating the coal for several hours in a Perrot furnace: next it was heated for two hours in a current of chlorine, and finally it was kept at a white heat for six hours. The product contained a trace of chlorine and 1/10 of 1 per cent of ash. The carbon and hydrogen were determined with the precautions already described. The following results are for the ash-free coal:

	I.	II.	Mean.
Carbon	99·08	99·04	99·06
Hydrogen	0·13	0·13	0·13
Oxygen ?	----	----	(0·81)
			100·00

The thermal results obtained, less the heat of combustion of the hydrogen content, were 8028, 8023 and 8027, mean 8026 calories for one gram of carbon. Considering that 0·81 per cent of the charcoal is oxygen in combination with hydrogen we have 8057 calories. Neither method of allowing for the hydrogen is to be considered as accurate, and the first correction is excessive.

Graphite.

Compact crystalline graphite associated with calcite was pulverized, digested with hydrochloric acid and washed. Thus purified it contained 0·32 per cent of ash. The analysis of the combustible portion gave

	I.	II.
Carbon	99·90	99·89
Hydrogen	0·01	0·02

The graphite is probably free from hydrogen as the amount given above is within the limits of error. Three calorimetric tests, using for each about 1·6 gram, gave 7836, 7848 and 7810, mean 7831 calories for the heat of combustion of one gram of graphite.

Second Series of Experiments.

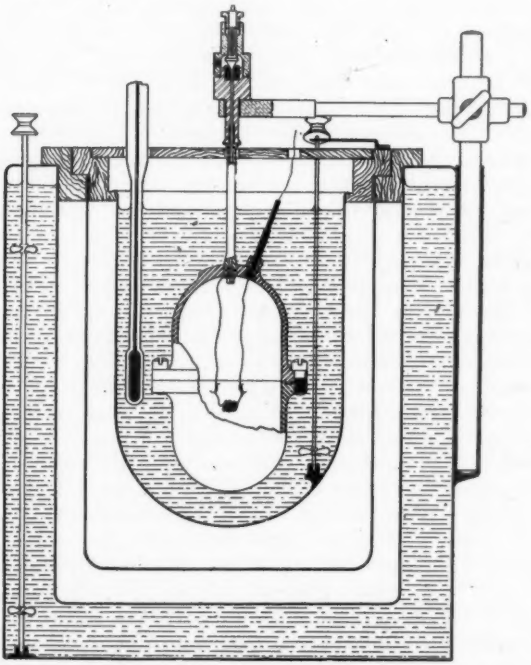
The carbon for this series was prepared as follows: Acetylene gas from carbide was passed through a long tube containing solid potassium hydroxide then pumped into the bomb through another tube two meters in length filled with fragments of potassium hydroxide. The one to two per cent impurity in the gas was chiefly nitrogen and oxygen. A little phosphureted hydrogen was also present. The gas at an initial pressure of about 10 atmospheres was fired by an electric spark between the neck of the bomb and the valve. The thermal effects for one gram of acetylene in four tests were 2063, 2080, 2075 and 2070, mean 2072 calories. This is 32 calories higher than the result obtained in the work* which yielded the carbon used in the first series of experiments. The hydrogen gas remaining after the explosion was free from acetylene but contained a little hydrocyanic acid.

The carbon was tested for hydrogen as follows: Two blank trials of the combustion apparatus were made using about 4 liters of oxygen and air in each. The sulphuric-acid absorption tube before the combustion tube gained 1·2 and 1·3 mlgs., and the one at the other end 2·1 and 0·6 mlgs., respectively, in the two tests. Then 2·11 grams of the carbon which had been heated to redness and cooled in a desiccator were placed in the combustion tube, and heated for a time in a current of dry air to drive off any water present. Next the absorption tubes were connected and the combustion was made in the usual way. The anterior tube gained 1·3 mlg. and the one through which the products passed gained 4·2 mlgs. The cause of the increase of the anterior tube was not evident. The oxygen and air used were dried by caustic potash and calcium chloride and then passed through a long U-tube filled with beads drenched with the same sulphuric used in the weighed tubes. It is evident that the gain of 4·2 mlgs., equivalent to 0·02 per cent of hydrogen, may be due to something other than water formed in the combustion of the substance, and we may assume that the carbon was either free from hydrogen or contained too little to be considered in the calorimetric results.

The carbon was repeatedly digested with a mixture of nitric acid, density 1·57, and potassium chlorate and was finally completely oxidized, leaving, however, a few minute transparent particles. When it was oxidized in other ways similar particles were found.

* Loc. cit.

The calorimeter used in this second series of experiments is shown in the figure. The bomb was silver plated and lined with pure silver a millimeter in thickness. The water equivalent of the calorimeter is less than one-tenth of the water it contained. Thermometer No. 1, described in the paper on hydrogen (loc. cit.) was used.



Experiment 1.—

Observed weight of carbon		1·5057 gram
Air condensed on "	−	0·0017 "
Reduction for weight in vacuum	+	0·0008 "
Corrected weight		1·5048 "
Observed weight of water		3255·5 grams
Reduction for weight in vacuum		3·2 "
Water equivalent of oxygen and carbon dioxide		1·7 "
Water equivalent of calorimeter		286·6 "
Water and water equivalent		3547 "
Oxygen		9·7 "
Iron wire to ignite the carbon		44 milligrams
Silver dissolved by HNO_3 formed		38 "

Minutes.	Temperature.	Temperature interval.
0	18·421	
1	18·426	21·811 − 18·436 + 0·007 = 3·382°
2	18·431	
3	18·436	
4	21·8	
5	21·810	Heat observed, 3547 × 3·382 = 11996^c
6	21·816	" of oxidation of iron − 70·4^c
7	21·813	" of formation of silver nitrate − 8·2^c
8	21·811	
9	21·809	Heat of combustion of 1·5048
10	21·807	gram of carbon 11917.4^c
11	21·805	Heat of combustion of 1 gram
12	21·803	of carbon 7919·6^c
13	21·802	
14	21·801	
15	21·399	

Experiment 2.—Carbon 1·4304, iron 0·040, silver dissolved 0·048, oxygen 10·5, water and water equivalent, 3637·6 grams.

Minutes.	Temperature.	Temperature interval.
0	19·263	
1	19·268	22·394 − 18·272 + 0·003 = 3·125°
3	19·272	
4	22·	Heat observed, 3637·6 × 3·125 = 11367·5^c
5	22·39	" of oxidation of iron −64· ^{c}
6	22·395	" of formation of silver nitrate − 10·4^c
7	22·394	
8	22·392	11293·1^c
9	22·392	For 1 gram of carbon 7895· ^{c}
10	22·392	
11	22·391	
12	22·390	
13	22·389	
14	22·388	

Experiment 3.—Carbon 1·5354, iron 0·031, silver dissolved 0·064, oxygen 10·6, water and water equivalent 3618 grams.

Minutes.	Temperature.	Temperature interval.
0	19·104	
1	19·108	22·466 − 19·112 + 0·010 = 3·364°
2	19·112	
3	22·25	Heat observed, 3618 × 3·364 = 12171 ^{c}
4	22·472	" of oxidation of iron −49·6^c
5	22·472	" of formation of silver nitrate − 13·6^c
6	22·470	
7	22·466	12107·8^c
8	22·463	For 1 gram of carbon 7885·7^c
9	22·461	
10	22·458	
11	22·456	
12	22·454	
13	22·451	
14	22·449	

Experiment 4.—Carbon 1·361, iron 0·032, silver dissolved 0·013, oxygen 10·5, water and water equivalent 3511·5 grams.

Minutes.	Temperature.
0	18·777
1	18·780
2	18·783
3	18·786
4	21·8
5	21·853
6	21·853
7	21·851
8	21·848
9	21·845
10	21·843
11	21·841
12	21·839
13	21·838

Temperature interval.

$21·848 - 18·786 + 0·008 = 3·070°$

Heat observed, $3511·5 \times 3·07$	$= 10780·3^c$
" of oxidation of iron	$- 51·2^c$
" of formation of silver nitrate	$- 2·7^c$
	$10726·4^c$
For 1 gram of carbon	$7881·3^c$

Summary of Results.

Experiment No.	First series.	Second series.
1	7869	7919·6
2	7919·5	7895
3	7881·7	7885·7
4	7903·4	7881·3
5	7888·8	
6	7889·4	
Average	7892·	7895·4

The mean of the results of the two series of experiments is 7894 calories for the heat of combustion of one gram of acetylene carbon at constant pressure and volume and at about 20° and in terms of the water calorie at this temperature, and for 12 grams it is 94,728 calories.

Art. XLVII.—*Reflection of Light by Colored Papers;* by Howard D. Minchin.

Although the subject of reflection of light by various surfaces has received much attention, the question of the reflecting power of colored papers and of wall papers in particular seems to have attracted little notice. The importance of the subject from an economic as well as from an artistic standpoint would seem to justify the attempt to settle certain features in the question even though the treatment be little more than qualitative.

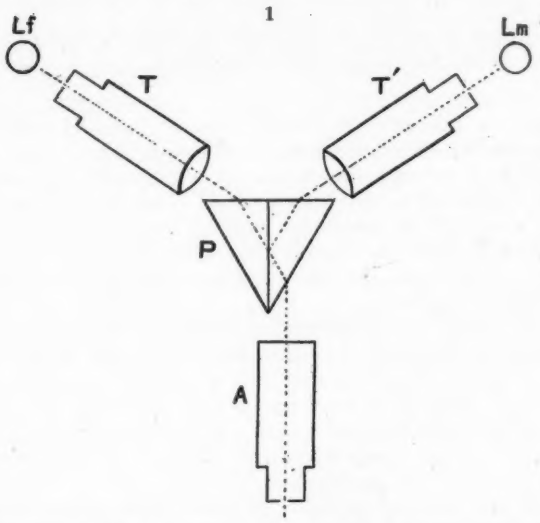
The investigation is complicated at the outset by our inability to specify definitely the exact sample of paper under examination as well as by our inability to reproduce such sample for purposes of subsequent comparison and measurement. Nevertheless it has been thought worth while to submit the result of a series of measurements upon the reflective powers of a set of ordinary commercial papers.

Under the head of metallic reflection the classic investigation of Hagen and Rubens,* Langley,† Nichols,‡ Jamin,§ Quincke,‖ and Drude,¶ are of the first importance. Wright,** studied diffuse reflection of light on matt surfaces, while the reflective powers of mercury and glass were investigated by Walbott,†† and Walker,‡‡ respectively. Investigations touching the reflection of light by colored papers are, so far as known to the author, confined to the writings of Abney,§§ Abney and Festing,‖‖ and of Kononowitsch,¶¶ but in none of these can be found any mention of the subject under consideration.

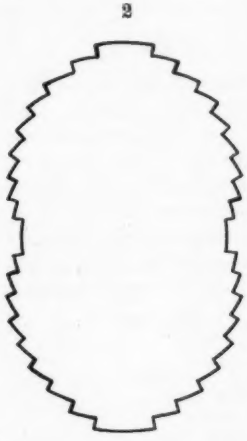
Apparatus and Method.

The measurements of the investigation here discussed were made by means of a Brace spectrophotometer consisting of two collimators T and T′, a telescope A, and a Brace prism P (fig. 1). The sources of light were two 220 volt 16 candle power incandescent lamps. One was permanently fixed at

* Hagen and Rubens, Ann. d. Physik., i, 352, 1900.
† S. P. Langley, Phil. Mag., xxvii, 10, 1889.
‡ E. L. Nichols, Wied. Ann., lx, 401, 1897.
§ J. Jamin, Ann. Chim. Phys. (3), xxii, 311, 1848.
‖ G. Quincke, Pogg. Ann. Jubelb'd., 336, 1874.
¶ P. Drude, Wied. Ann., xxxix, 481, 1890.
** H. R. Wright, Phil. Mag. (5), xlix, 199, 1900.
†† H. Walbott, Wied. Ann., lxviii, 471, 1899.
‡‡ B. Walker, Wied. Ann., lii, 762, 1894.
§§ Abney, Roy. Soc. Proc., lxvii, 118, 1900.
‖‖ Abney and Festing, Phil. Trans., clxxii, 887, 1882.
¶¶ Kononowitsch, Wied. Ann., lxvi, 317, 1897.



collimator T, in which the slit was adjusted to some desired width. The second lamp was used at collimator T′, first directly in front of the slit and afterwards at one side, the light from it being reflected into T′ by the reflecting surface. Care was taken so to shield the lamps that no light reached the prism P, except that coming through the slits. To obtain a more uniform field ground glass plates were placed directly in front of the slits.



A revolving disk (fig. 2) similar to that described by Brace* was placed in front of T, by means of which the intensity of the light admitted to the slit could be varied by tenths, giving 0·1, 0·2, 0·3, etc., of the full intensity. The disk was driven by an electric motor as described by Murphy.†

With the lamps placed directly in front of the two collimators and the slit in collimator T set at a definite width, the slit in T′ was calibrated by means of the rotating disk, according to the method described by Capp,‡ for the five colors:

* Brace, Astro-Physical Journal, xi, 6.
† Murphy, " " " vi, 5.
‡ Capp, " " " vii, 25.

red, $\lambda = 0{\cdot}0006562^{mm}$
yellow, $\lambda = 0{\cdot}0005893^{mm}$
green, $\lambda = 0{\cdot}0005460^{mm}$
blue, $\lambda = 0{\cdot}0004862^{mm}$
violet, $\lambda = 0{\cdot}0004357^{mm}$

The slit in T′ was adjusted for a match first with the total light admitted at T, then with 0·5, 0·3, 0·2, and 0·1, the total light.

3

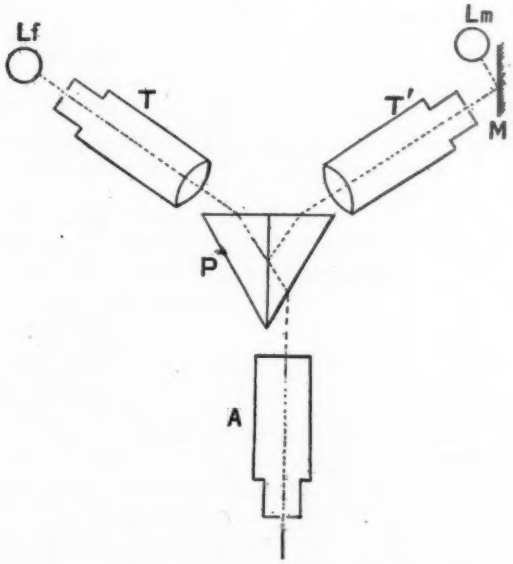


Table I gives the required width of T′ in mm. for a match in the different colors when T is $0{\cdot}2^{mm}$ in width. All values recorded are the average of eight readings. *Data:*

TABLE I.

Width of T′ in mm.

Color.	For intensities of				
	1·0	0·5	0·3	0·2	0·1
Red	0·263	0·146	0·095	0·071	0·041
Yellow ...	0·293	0·165	0·099	0·079	0·042
Green	0·307	0·171	0·105	0·082	0·046
Blue	0·334	0·183	0·118	0·090	0·055
Violet	0·368	0·189	0·103	0·105	0·048

The lamp at T′ was next placed at one side and a mirror fixed at T′ to reflect the light into the slit. Fig. 3 shows the arrangement.

The length of the light path was kept constant and the angle of incidence was made 45°. The results are given in Table II.

TABLE II.

Width of T′ when mirror is used.

Color.	Intensities at T.			
	1·0	0·5	0·3	0·1
Red	0·569	0·276	0·190	0·081
Yellow	0·607	0·305	0·198	0·084
Green	0·621	0·332	0·209	0·091
Blue	0·685	0·381	0·238	0·109
Violet	0·810	0·392	0·204	0·094

The colored paper was substituted for the mirror and adjustments of T′ made as before. The following tables give the results for the paper used:

(The interrogation point denotes some light, but not sufficient for a match. 0 means no trace of color noticeable.)

Width of T′ when T = ·1mm.

Paper.	Color reflected.	Intensities at T.				
		0·1	0·2	0·3	0·4	0·5
Deep red	Red	1·287	1·878	2·697	?	--
	Yellow	?	----	----	--	--
	Green	?	----	----	--	--
	Blue	?	----	----	--	--
	Violet	0	0	0	0	0

Width of T′ when T = 0·2mm.

Paper.	Color reflected.	Intensities at T.				
		0·1	0·2	0·3	0·4	0·5
Light red	Red	0·460	0·889	--	1·680	2·009
	Yellow	?	----	--	----	----
	Green	*	----	--	----	----
	Blue	2·235	----	--	----	----
	Violet	?	----	--	----	----

Width of T′ when T = 0·2mm.

Paper.	Color reflected.	Intensities at T.				
		0·1	0·2	0·3	0·4	0·5
Dark green	Red	1·903	?	--	--	--
	Yellow	2·650	?	--	--	--
	Green	1·810	?	--	--	--
	Blue	2·122	?	--	--	--
	Violet	2·418	?	--	--	--

* When T′ was narrow a little green was seen, but when T′ was widened for a match all trace of green disappeared.

Width of T′ when T = 0·1mm.

Paper.	Color reflected.	Intensities at T. 0·1	0·2	0·3	0·4	0·5
Dull green	Red	1·424	?	--	--	--
	Yellow	1·302	?	--	--	--
	Green	1·056	2·091	?	--	--
	Blue	1·450	2·278	?	--	--
	Violet	?	----	--	--	--

Width of T′ when T = 0·1mm.

Paper.	Color reflected.	Intensities at T. 0·1	0·2	0·3	0·4	0·5
Light green	Red	1·289	2·120	?	----	----
	Yellow	1·176	2·204	?	----	----
	Green	0·683	1·299	2·029	?	----
	Blue	0·782	1·280	1·912	2·129	2·710
	Violet	Just a slight trace				

Width of T′ when T = 0·2mm.

Paper.	Color reflected.	Intensities at T. 0·1	0·2	0·3	0·4	0·5
Dark blue	Red	1·847	?	--	--	--
	Yellow	?	--	--	--	--
	Green	?	--	--	--	--
	Blue	4·667	--	--	--	--
	Violet	?	--	--	--	--

Width of T′ when T = 0·1mm.

Paper.	Color reflected.	Intensities at T. 0·1	0·2	0·3	0·4	0·5
Light blue	Red	1·213	2·061	?	----	----
	Yellow	1·088	1·980	?	----	----
	Green	0·936	1·684	2·521	?	----
	Blue	0·789	1·505	2·096	?	----
	Violet	1·036	1·111	1·631	2·117	2·886

Discussion of Data.

Table II shows that approximately one half the incident light was reflected by the mirror. Both Table I and Table II show that as the violet end of the spectrum was approached the width of T′ had to be increased to procure a match.

Because of the small amount of light reflected by the papers it became necessary to cut down the intensity of the light admitted at T. Each of the tables gives the greatest intensities that could be used and allow the obtaining of a match.

The deep red paper reflected red light only, to a sufficient degree to allow of a match.

The intensity of the light reflected by the light red paper was very low and it was necessary to narrow T to 0·1^{mm}. A match was then obtained for red and blue.

The green papers reflected all colors in considerable amounts. The dark green reflected red and green light about equally, while the light green reflected less of the red and reflected green and blue in about the same amounts, but as the intensity of the light admitted at T was increased more blue than green was reflected.

The dark blue paper reflected red light of an intensity about two and one-half times the intensity of the blue reflected. The other colors were reflected in very small amounts.

With the light blue paper all the colors were reflected when the intensity at T was 0·1 or 0·2, and with intensities at T of 0·4 and 0·5 a match was obtained with violet light only.

A comparison of all the papers used can be made only for an intensity of light admitted at T of 0·1. The following table gives the width of T′ in terms of T for a match in the different colors. For example, in the red when light was admitted directly, T′ was 0·21 times the width of T for match, when the mirror was used T′ was 0·41 times the width of T, etc.

T′ in terms of T.

Light from.	Colors.				
	Red.	Yellow.	Green.	Blue.	Violet.
Direct	0·21	0·21	0·23	0·28	0·24
Mirror	0·41	0·42	0·46	0·55	0·47
Deep red	6·44	?	?	?	?
Light red	4·60	?	?	22·34	?
Dark green	9·52	13·25	9·05	15·61	12·09
Dull green	14·24	13·02	10·56	14·50	?
Light green	12·89	11·76	6·83	7·82	?
Dark blue	9·24	?	?	23·34	?
Light blue	12·13	10·88	9·36	7·89	10·36

The dark green and the light blue papers are the only papers that reflected all colors sufficiently to obtain a match. The light green and the dull green papers are the next in order, both the latter reflected very little violet light. The light reflected by the dark green and the light blue papers is more nearly white light than that from any of the other papers used.

Less than 0·02 of the incident light was reflected by the best paper used, when all conditions were the best possible.

The observations embodied in this paper were made in the Physical Laboratory of the University of Michigan, at the suggestion of Professor Reed, to whom thanks are due for his interest and assistance during the progress of the investigation.

Physical Laboratory, University of Rochester, January, 1905.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *New Experiments in Preparing Diamonds.*—In his examination of the Canyon Diablo meteorite, Moissan noticed that the diamonds found in it occurred in fissures containing sulphide of iron, and it seemed possible that sulphur might have had an influence in the formation of these crystals. He has, therefore, made some new experiments upon the formation of diamonds by crystallization from iron saturated with carbon in the electrical furnace and rapidly cooled with water, and has modified his experiments of several years ago by additions of sulphide of iron, silicide of iron, or phosphide of iron to the fused metal before cooling. The results showed that the production of diamonds was somewhat better in the presence of sulphur than had formerly been the case without this addition, and silicon appeared also to exert a favorable influence, but in this case more difficulty was encountered in the separation of the diamonds from the ingot, on account of the presence of carbide of silicon. No diamonds were obtained in two experiments where phosphide of iron was added. Some of the diamonds produced in the presence of sulphur were large enough to be separated with the naked eye by means of a steel point, while the largest of those made in the presence of silicon had a length of $\cdot 75^{mm}$. Their size is of the same order as that of those from the meteorite, and they are practically microscopic objects. Moissan has confirmed his previous conclusion that the artificial substance is actually diamond, and he finds that, like the natural substance, it often shows weak double refraction. He regards the diamond as a form of carbon which has been liquefied under high pressure, since he has shown previously that at ordinary pressure all forms of carbon vaporize without becoming liquid, and all produce graphite.—*Comptes Rendus*, cxl, 277. H. L. W.

2. *Atomic Weights of Sodium and Chlorine.*—T. W. Richards and R. C. Wells have made a very elaborate investigation in revising these important atomic weights. As is usual with the work of Richards, the greatest precautions have been taken in purifying materials, detecting sources of error and avoiding or making accurate allowances for them, and in the use of varied methods and materials. The description of the work inspires the utmost confidence in it, as well as admiration for the skill and patience displayed in carrying it out. As a result of their research it appears that the work of Stas on the atomic weights in question was slightly erroneous. From a study of the ratios AgCl : NaCl, Ag : NaCl, and Ag : AgCl, they find that when the atomic weight of silver is taken as 107·930, sodium is 23·008, and chlorine is 35·473, whereas the previously accepted numbers are 23·05 and 35·45. Many other atomic weights are affected, in

their second decimal places, by these changes, and a recalculation of the atomic weights will be necessary soon. Richards suggests, however, that this systematic recalculation be delayed until a few other new data should have been obtained—in particular, new analyses of potassium chloride, silver chlorate, the bromides, sulphides and sulphates, and similar important compounds. Some of these are already being made, and others will be undertaken at once by Professor Richards.—*Carnegie Institution of Washington.* Publication No. 28. H. L. W.

3. *The Origin of Radium.*—A continuation of the investigations of Dr. B. B. Boltwood upon the relative quantities of uranium and radium in various minerals, an account of which appeared in the preceding volume of this Journal, shows that these quantities are proportional to one another, within the limits of experimental errors, even in minerals containing much thorium and very small amounts of uranium. The more recent experiments were the examination of twenty-two specimens of minerals where the accurately determined percentages of uranium vary from 74 to 0·3 per cent, and in this series allowance is made for the emanation lost at ordinary temperatures by the various samples. The author says that the inevitable and only possible conclusion from the results is that uranium is the parent of radium, and that the participation of thorium in the production of radium, which has been suggested by some, is entirely excluded. He also mentions experiments made to determine whether radium is formed directly from uranium. These showed no evidence of this change after a period of seven months and confirm the results of similar experiments by Soddy, so that it is probable, as suggested by Rutherford, that one or more intermediate changes exist between the uranium atom and the radium atom. Attention is called to the persistent appearance of lead as a constituent of uranium-radium minerals as an indication that this metal may be one of the final products of the disintegration of uranium.—*Phil. Mag.* (6), ix, 599. H. L. W.

4. *Marceli Nencki, Opera Omnia—Gesammelte Arbeiten von* Prof. M. Nencki—Erster Band, 1869–1885; Zweiter Band, 1886–1901. Large 8vo, pp. xliii + 840, and xiii + 893. Braunschweig, 1905. (Friedrich Vieweg und Sohn.)—These two sumptuous volumes, edited by N. Sieber and J. Zaleski, contain a fine portrait of Nencki as a frontispiece, a sketch of his life, a complete collection of his scientific writings, as well as numerous articles by pupils working under his direction. The work is an important and useful one, because Nencki's publications are scattered through many different journals, and because of the scientific value of his researches. Nencki's work covers a wide field, and the articles have been systematically indexed by the editors. There are many important investigations in pure chemistry—it is said that he took pride in having made over one thousand elementary analyses—but it is well known that his most important work was in the lines of physiological and medical chemistry, and

the book will be particularly useful to those interested in these branches of science. H. L. W.

5. *Manual of Chemical Analysis as Applied to the Assay of Fuels, Ores, Metals, Alloys, Salts, and other Mineral Products;* by EUGÈNE PROST; translated by J. CRUICKSHANK SMITH. 8vo, pp. 300. London, Maclaren & Sons; New York, D. Van Nostrand Company, 1904.—The object and scope of this work are set forth in the title. It should serve as a useful book of reference for analytical chemists engaged in technical work, for many of the methods of analysis are well selected and carefully described. A good feature of the book is the introduction of typical analyses of many commercial products, which give the chemist an idea of the ingredients to be looked for as well as the extent to which they are liable to occur. The book may be criticized on account of failing to include certain useful and reliable methods. For instance, Drown's method for the determination of silicon in pig iron is not given, while tared paper filters are recommended for weighing precipitates in cases where the Gooch crucible would give far better service, and other antiquated features from an American point of view are to be noticed. Not all of the methods are described in such a way that they would give a satisfactory degree of accuracy when implicitly followed, and in some cases the directions are decidedly lacking in completeness, or the methods are faulty in principle. The book is, therefore, not a perfect one, although it contains much that is useful. It seems unfortunate that the translator should have employed incorrect chemical nomenclature in some cases; for instance, chloride of soda for sodium chloride. H. L. W.

6. *Radiation Pressure.*—Professor POYNTING discusses simple methods of showing the pressure of light, and applies his theory of the stream of momentum. Theory and experiment seem to indicate that when a source is sending out waves it is pouring out with them forward momentum as well as energy, the momentum being manifested in the reaction, the back pressure against the source, and in the forward pressure when the waves reach an opposing surface. The wave train may be regarded as a stream of momentum traveling through space. Radiation pressure has not succeeded in explaining the repulsion of comet's tails. Professor Poynting suggests the following explanation of Saturn's rings: Let us imagine that a small sun while still radiating much energy on its own account has captured and attached to itself as satellite a cometary cloud of dust. Then, if the cloud consists of particles of different sizes, while all will tend to draw into the primary, the larger particles will draw in more slowly. But if the larger particles are of different sizes among themselves, they will have different periods of revolution, and will gradually form a ring all round the planet on the outside. Meanwhile the finer particles will drift in, and again differences in size will correspond to difference in period and they too will spread all around, forming an inner fringe to the ring. If there are several grades

of dust with gaps in the scale of size, the different grades will form different rings in time.—*Phil. Mag.*, April, 1905. J. T.

7. *Spontaneous Ionization of Air in closed Vessels and its Causes.*—The conductivity of air and other gases is generally attributed to the presence of free ions, and as these free ions are continually recombining there is some agency which is splitting up the combinations. Ionization in which no artificial ionization agent is employed has been called spontaneous ionization. The hypothesis that the ionization is due to a penetrating radiation constantly passing through the atmosphere has been advanced and is largely adopted. ALEXANDER WOOD of Emmanuel College, Cambridge, believes from a careful inspection of indirect evidence that all matter is radio-active and that the disintegration processes going on in radium and the other radio-active elements are going on also, though to a much smaller extent, in all matter. —*Phil. Mag.*, April, 1905. J. T.

8. *Radio-activity and Chemical Change.* — N. R. CAMPBELL finds that there is no evidence that chemical change is accompanied by radio-activity; and that the spontaneous leak increase which has led some investigators to suggest such a connection is due to the heating of the walls of the vessels.—*Phil. Mag.*, April, 1905. J. T.

9. *Helium Tubes as Indicators of Electric Waves.* — Geissler tubes filled with argon, neon and other gases have been used by various investigators of electric waves along wires. ERNST DORN finds that tubes filled with helium, $\cdot 5\text{-}5^{mm}$ pressure are very sensitive and do not require a dark room.—*Ann. der Phys.*, No. 4, 1905, pp. 784–788. J. T.

10. *The Specific Heat of Water and the Mechanical Equivalent of Heat.*—The leading article in the Annalen der Physik, No. 4, 1905, by C. DIETERICI, is a careful consideration of this subject, and is remarkable for the use the author makes of vessels of amorphous quartz. The method adopted in determining the specific heat of water was to enclose a definite quantity in a quartz cylinder and after raising it to a measured temperature to suddenly immerse it in a Bunsen ice calorimeter. The value $419{\cdot}25 \times 10^5 \frac{\text{erg.}}{\text{cal.}}$ was obtained for the mechanical equivalent of heat.—*Ann. der Phys.*, No. 4, 1905, pp. 593–621. J. T.

11. *Photograph of the Solar Corona without a Total Eclipse.* —In the opinion of M. J. Janssen, M. A. HANSKY has succeeded in photographing the corona of the uneclipsed sun. The results were obtained at the observatory of Mt. Blanc by the use of the selective absorption of different screens. The direct rays of the sun were shut off by a disc. The negatives show distinct halos around the disc of the sun. Photographs illustrate the paper.—*Comptes Rendus*, No. 12, 1905, pp. 768–778. J. T.

12. *Kristallinische Flüssigkeiten und Flüssige Kristalle;* von Dr. RUDOLF SCHENCK. 159 pp., 8vo, with 86 figures in the text. —The highly important work of Lehmann on "Flüssige Kristalle" was published a year ago and presented a large array of interest-

ing and novel phenomena in regard to liquids, which under certain conditions exhibit the phenomena of double-refraction. The present volume is a further contribution to the same remarkable subject in which the observations of the author and his associates, particularly as the physico-chemical properties of the liquids, are given in detail. These phenomena, in general, are exhibited through a definite interval of temperature included between the point of fusion and the "Klarungs-punkt," or that at which the transition to the transparent isotropic fluid takes place. The chapter discussing in detail the properties of these two points, their relation to the density, their dependence upon the pressure, upon the presence of foreign constituents and other related points is of great interest. Another chapter not less important, treats of the viscosity and other properties of the "crystalline" and isotropic fluids. The author wisely makes free use of the work of Lehmann and by this means is enabled, in a limited space, to present an excellent summary of the entire subject.

13. "*N*" *Rays: A Collection of Papers communicated to the French Academy of Sciences with additional Notes and Instructions for the Construction of Phosphorescent Screens;* by R. BLONDLOT; translated by J. GARCIN. Pp. xii, 83; with phosphorescent screen (frontispiece) and other illustrations. London and New York, 1905 (Longmans, Green & Co.).—The subject of the "N"-rays* is one that has excited much attention, although there have been some to raise the question as to the objective reality of the phenomena described. In any case, however, it is a matter of great interest to have the original papers of Professor Blondlot translated and brought together in a single volume; this work has been well done by M. Garcin. Fifteen papers are included, all reprinted as they were originally published in the Comptes Rendus of the French Academy. A number of plates are introduced which show the phenomena described, and the frontispiece consists of a phosphorescent screen of calcium sulphide for use in the observation of the "N"-rays, and prepared in accordance with the methods described in the closing pages of the volume.

14. *Das elektrische Bogenlicht, seine Entwickelung und seine physikalischen Grundlagen;* von W. B. VON CZUDNOCHOWSKI, Zweite Lieferung, pp. 99–194; dritte Lieferung, pp. 195–290. Leipzig, 1905 (S. Hirzel).—The second and third parts of this exhaustive work on the electric arc-light, announced in an earlier number of this Journal, have recently been issued. These are largely devoted to a historical discussion of the development of the arc-light from the time of Volta and Davy down to 1900. The subject has now reached so definite and relatively simple a stage that it is interesting to recall the many and varied attempts to solve the problems which had to be made before success was

* Named in allusion to the city (Nancy) at the university in which the author is professor.

finally attained. The prominent forms of regulators, devised from time to time, are described fully and in historical order. The various special problems which have arisen, as the division of the electric light, the application of the light for signals at sea, the relation of light intensity to distance of visibility, and so on, are also treated in detail. The three parts now issued complete about one-half of the work as planned.

15. *The new Knowledge: A popular Account of the new Physics and the new Chemistry in their Relation to the new Theory of Matter;* by ROBERT KENNEDY DUNCAN. 263 pp., 8vo. New York, 1905 (A. S. Barnes & Co.).—There is no reason why, at the present day, the intelligent laymen should not acquire a reasonably good knowledge of the progress that is being made in the different branches of science, for books are not wanting which put before him the facts in a form requiring a minimum of preliminary training. The volume at hand is one having this object, but its scope is broader than usual, and the nature of matter, as now understood, and the light thrown upon the subject by the phenomena of electricity and radio-activity are presented with much system and clearness, and with a style to attract the reader. The closing chapters reach out beyond the earth to some of the problems of the stellar universe.

16. *Percentage Tables for Elementary Analysis;* by LEO F. GUTTMANN, Ph.D. 43 pp. 8vo. New York and London, 1904 (Whittaker & Co.).—These tables, reproduced here from the German edition, will be found most useful by the practical chemist, as they give him at once with all necessary accuracy (to four decimal places), from the amount of carbon dioxide and water yielded on combustion by the substance under examination, the percentage of carbon and hydrogen which it contains. A proportional table opens the volume and one for the reduction of volumes of nitrogen to grams is added at the end.

II. GEOLOGY AND MINERALOGY.

1. *United States Geological Survey,* CHARLES D. WALCOTT, Director.—The following publications have been recently received; notices of some of them are deferred to a later number.

GEOLOGIC FOLIOS. No. 117. Casselton-Fargo Folio, North Dakota–Minnesota; by C. M. HALL and D. E. WILLARD.

No. 118. Greeneville Folio, Tennessee–North Carolina; by ARTHUR KEITH.

No. 119. Fayetteville Folio, Arkansas–Missouri; by G. I. ADAMS and E. O. ULRICH.

PROFESSIONAL PAPERS. No. 32. Preliminary Report on the Geology and Underground Water Resources of the Central Great Plains; by N. H. DARTON. 433 pp. 4to, 72 plates, 18 figures.

No. 39. Forest Conditions in the Gila River Forest Reserve, New Mexico; by THEODORE F. RIXON. 89 pp. with folded map and diagram.

BULLETINS. No. 238. Economic Geology of the Iola Quadrangle, Kansas; by G. I. ADAMS, E. HAWORTH and W. R. CRANE. 80 pp., with 11 plates, 13 figures.—The Iola Quadrangle embraces an area of 944 sq. miles in the southeastern portion of Kansas. It lies in the prairie plains region characteristic of the eastern portion of the state, and is of especial interest because of its extensive oil and gas resources. The geological structure and relations of the oil and gas are in general similar to those prevailing over the entire Kansas–Indian Territory field, and hence the facts brought out in this bulletin, which is issued in advance of the Iola folio now in preparation, will be found useful by those interested in other portions of the field.

Briefly stated, the rocks exposed by outcrops and revealed by the drillings belong to the Pennsylvanian series of the Carboniferous. This series, known as the Coal Measures, contains beds of workable coal chiefly in the lower portions; the Boone limestone of the Mississippian series lies below the Coal Measures. The oil and gas of the region are largely confined to the Cherokee shales, which here form the lowest section of the Coal Measures and have a thickness of some 450 feet. The oil and gas reservoirs are associated with beds of sandstone, of varying extent and thickness, and sometimes of very local extent. Many facts of an economic importance are brought out in the bulletin, particularly with reference to the gas wells. This region also affords considerable quantities of Portland cement and there are important brickmaking plants.

No. 242. Geology of the Hudson Valley between the Hoosic and the Kinderhook; by T. NELSON DALE. 63 pp., 3 plates including a geological map, 17 figures.

No. 246. Zinc and Lead Deposits of Northwestern Illinois; by H. FOSTER BAIN. 56 pp., 5 plates, 3 figures.—The region covered by this paper lies in the extreme northwestern portion of the state, including a part of Jo Daviess county. Another region, also yielding zinc and lead minerals, is found in the southern portion of the state (in Hardin, Pope and Saline counties) and forms part of the Kentucky–Illinois fluorspar, lead and zinc field. The former region, here described, has been known to yield lead since 1700 and mining operations have been carried forward for upwards of one hundred years. Much has been written by different authors as to the mineralogical nature of the deposits, the method of their occurrence and their origin; the present paper gives a convenient and concise summary of the facts as now known, upon what the writer's observations have served to throw additional light.

No. 249. Limestones of Southwestern Pennsylvania; by FREDERICK G. CLAPP. 52 pp., 7 plates.—The subject developed in this paper is the character and distribution of limestones suitable for Portland cement, or for other economic uses. Sixteen layers of limestone are recognized and named, varying in thickness from 60 to 6 feet; the occurrences are described and the prospective value of each estimated.

No. 250. The Petroleum Fields of the Pacific Coast of Alaska with an account of the Bering River Coal Deposits; by GEORGE C. MARTIN. 64 pp., 7 plates, 3 figures.—The observations made thus far are preliminary only, but they serve to show that at several points on the Alaska coast, conspicuously near Controller Bay, about 100 miles west of Mt. St. Elias, petroleum occurs in some quantity, and the region may prove to be an important source in the future; explorations thus far made are, however, inconclusive. The best coal thus far found on the Pacific coast is that of Bering river which flows into Controller Bay. Petroleum fields have also been somewhat developed on the western shore of Cook Inlet and on Cold Bay opposite Kodiak Island.

No. 252. Preliminary Report on the Geology and Water Resources of Central Oregon; by ISRAEL C. RUSSELL. 138 pp. 24 plates, 4 figures.—This bulletin gives, as the result of a rapid reconnoisance, an interesting and well illustrated account of a little known region in central and eastern Oregon. It includes the extreme northern part of the Great Basin, which has no external outflow, and also a part of the drainage area of the Deschutes and Crooked rivers. Much of it is an arid region, conspicuously the "Great Sandy Desert," which has a length of 150 and a width of 30 to 50 miles. Of the hills or mountains of the region, much the greater number owe their origin to volcanic eruptions, the cones being particularly abundant to the west in the neighborhood of the Cascade Mountains. The volcanic rocks are mainly rhyolites, andesites and basalts, the last named being in general the latest, though certain andesites and andesitic tuffs are the youngest of all the lava outflows. In the west-central part of the state an extensive shell of pumice, similar to that about Crater lake described by Diller, forms a thick mantle over the surface. The sedimentary formations consist of soft, or partially consolidated beds, of Tertiary age. Interesting observations, with excellent views, are given of the present glaciers, particularly on the three peaks of the Cascade Mountains known as the Three Sisters. In regard to the extent of former glaciation the writer states "that during a former period, which can be safely correlated with the Glacial epoch, great snow fields covered the summit portion of the Cascade Mountains throughout their entire extent across Oregon, and from this névé region large alpine glaciers flowed eastward down the mountains. Glaciers also occurred on the west side of the range, but no new facts concerning them can be presented at this time. The conditions were of the same general character as existed on the Cascade Mountains in Washington, but the eastward-flowing ice streams were seemingly less extensive. An instructive suggestion in reference to the glaciers on the east side of the Cascade Mountains in Oregon is furnished by the fact that in the southern portion of the state, in the vicinity of Mounts Scott and Mazama, the eastward-flowing glaciers are larger and of greater length than farther north in the vicinity of the Three Sisters peaks and

Mount Jefferson. If this conclusion is sustained by future studies, an explanation of it will perhaps be suggested by comparing the present climatic conditions of the two regions."

No. 258. The Origin of certain Place Names in the United States (second edition); by HENRY GANNETT. 334 pp. This paper is a second edition of that published as Bulletin No. 197; it contains a large amount of useful geographical information.

No. 259. Report on Progress of Investigations of Mineral Resources of Alaska in 1904; by ALFRED H. BROOKS and others. 196 pp., 3 plates, 10 figures.—This bulletin gives an account, by the different geologists at work, of the information gathered during the last season in regard to the various mineral deposits of Alaska. Nine parties were in the field, five of them engaged in geologic work, two in topographic surveys, one was a combined geologic and topographic party and one studied the methods and costs of placer mining. The larger part of the bulletin is devoted to the gold placers, but an account is also given of the Treadwell ore deposits on Douglas Island, as, too, of the recent development of tin deposits in Alaska. Further, the coal and petroleum resources of Alaska are discussed in detail (see also Bulletin No. 250).

No. 261. Preliminary Report on the Operations of the Coal-testing Plant of the U. S. Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904; E. W. PARKER, J. A. HOLMES, M. R. CAMPBELL, Committee in charge. 192 pp.

No. 264. Record of Deep Well Drilling for 1904; by M. L. FULLER, E. F. LINES and A. C. VEATCH. 106 pp.—The work of the Survey, in regard to the accummulation of geological and physical data of deep wells, although only recently inaugurated, is now so well organized that a very large amount of useful material is promptly brought together and given to the public. The paper now issued is the first of the series planned and presents the material received during the first six months of the work. A tabular summary is given for 358 wells and detailed records are added of a number of selected cases yielding information of importance.

WATER-SUPPLY PAPERS. No. 109. Hydrography of the Susquehanna Drainage Basin; J. C. HOYT and R. H. ANDERSON. 210 pp.

No. 111. Underground Waters of Washington; HENRY LANDES. 85 pp.

No. 113. Disposal of Strawboard and Oil-well Wastes; R. L. SACKETT and I. BOWMAN. 52 pp.

No. 114. Underground Waters of the Eastern United States; MYRON L. FULLER. 285 pp.

No. 115. River Surveys and Profiles made during 1903; arranged by W. C. HALL and J. C. HOYT. 115 pp.

No. 116. Water Problems of Santa Barbara, California; J. B. LIPPINCOTT. 99 pp.

No. 117. Lignite of North Dakota and its Relation to Irrigation; by F. A. WILDER. 59 pp.

No. 120. Bibliographic Review and Index of Papers relating to Underground Waters, U. S. Geol. Survey, 1879–1904; by MYRON F. FULLER. 128 pp.

No. 121. Preliminary Report on the Pollution of Lake Champlain; by M. O. LEIGHTON. 119 pp.

No. 122. Relation of the Law to Underground Waters; by D. W. JOHNSON. 55 pp.

2. *Contributions to Devonian Paleontology;* by H. S. WILLIAMS and E. M. KINDLE. Bull. U. S. Geol. Surv., No. 244, 1905, pp. 1–144.—The purpose of this Bulletin is to present the evidence regarding "the nature of the changes in sedimentation, in fossils and in sequence of faunas southward along the Devonian formations in the southern Appalachians." The Devonic sections of the Falls of Ohio region, of southwestern and central western Virginia, east-central Kentucky, and West Virginia, are analyzed and compared with one another. Then the upper Devonic sections in central and northern Pennsylvania are compared with those of New York. This Bulletin will have lasting value because of the many sections it describes in detail and the many faunules listed.

The fossils from the Helderbergian and Oriskanian horizons in Virginia and West Virginia led Professor Williams to conclude "that the subdivisions of the Rensselaeria fauna [Helderbergian and Oriskanian], which in the northern Appalachian region have determined the division of the strata into numerous separate formations, are not universal. Future investigations probably will show that the composition of the local faunules is determined rather by environmental conditions recorded by the differing characters of the sediment than by actual epochs in their history" (p. 49). The present writer will state that he has collected at nearly all of the southern localities described in this Bulletin and at many others, and finds no great difficulties in correlating any one of the southern faunules with the minor horizons of the New York Helderbergian, and this irrespective of the nature of the sediments. In regard to a complete Oriskanian development New York is a poor standard, whereas the Cumberland region is far better. Combining the New York and Maryland sections, the writer is able to state that the New Scotland, Coeymans, and Manlius occur at Big Stone Gap, Va. The "faunule of zone 2 of section 1376 A" and 1376 B2, on p. 28, are unmistakably New Scotland and not "Oriskany." On the "coarse sandstone" rests the Chattanooga Black shale. No Oriskany was seen about Big Stone Gap. To the northeast, near Bluefield, W. Va., there may be a little Lower Oriskany, but in the region of Covington, Va., there probably is not less than 35 feet of typical or Upper Oriskany. At the Low Moor Iron Co. mines, the writer collected *Spirifer arenosus, Meristella lata, Rensselaeria* sp. undet., *Eatonia singularis, Leptæna rhomboidalis,* and *Diaphorostoma ventricosa.*

There is considerable evidence of an erosion interval in the

southern Appalachians before the Black shale invasion, for in the region of Covington, Va., this may be seen resting at times on the Oriskany or the Becraft limestone, which is very well developed here. About Cumberland, Md., the maximum thickness for the Oriskany is about 300 feet. In sections only a few miles apart the thickness will vary from this down to 50 feet, and these thinner sections always carry a Lower Oriskany fauna, indicating a land interval here subsequent to the Upper Oriskany and before the Marcellus. The writer knows of no typical Onondaga (Corniferous) faunas south of northeastern Pennsylvania, and the faunules listed in this Bulletin, as, for instance, 1382 B3 and 1383 A2 and 3, are decidedly more Marcellus than Onondaga. Owing to the irregular pre-Marcellus erosion producing an uneven topography, it follows that the invading base of the Black shale will be different in different places. It is the writer's working hypothesis that owing to the Onondaga erosion interval and the low-lying fold which delimited the western boundary of the Cumberland Basin, the base in different localities may be anywhere between basal Marcellus and the higher Devonic. The Helderbergian and Oriskanian deposits are in full development in Maryland, but thin out rapidly southward, and none attain very far south of the Tennessee-Virginia boundary line. The Manlius, Coeymans, and New Scotland are typically present as far south as Hancock county, Tenn. The Becraft is in full force about Covington, Va., but is gone before Big Stone Gap is reached. The Lower Oriskany is present in the Hicksville, Va., faunule 1379 A1, but no Upper Oriskany. In other words, the waters of the Cumberland Basin extend from Hancock county, Tenn., north into Pennsylvania, throughout Manlius, Coeymans, and New Scotland time. With the Becraft there begins an emergence at the south, slowly dissipating the sea to the north, so that Oriskany sediments do not appear much south of Covington, Va. In Maryland the sea is continuous from the early Siluric to the end of Oriskany time, when emergence also sets in here and affects the Appalachian trough as far north as northeastern Pennsylvania.

Along the eastern side of the Cincinnati axis the invading Black Shale is never older than the Genesee. Here, again, the base is variable, but apparently is always within the time of the Genesee. This variability is due not only to the erosion unconformities pointed out by Dr. Kindle, but also to the transgression of the Genesee sea upon the Cincinnati axis.

Several species of the *Buchiola speciosa* (= *B. retrostriata*) fauna have their first appearance in the Marcellus and are apt to recur throughout the higher Devonic whenever the Black shale conditions prevail. Most of its species have a long range, as may be seen from the table on pp. 51, 52, of this Bulletin. Here 25 species are positively identified. If *Anoplotheca acutiplicata* occurs in this fauna in Virginia (can it be a Vitulina?) no particular time value can be assigned to it against the 24 other asso-

ciated forms, none of which are known to appear before Marcellus time. It therefore seems to the writer unwarranted to conclude, as does Professor Williams, that "the black shales range from as low as the Onondaga." Admitting this identification, then, not only does the form in question persist into Marcellus or later time, but there are, as is well known to Professor Williams, many other Onondaga species persisting into Hamilton time in other faunules than those listed in this Bulletin (*Chonetes mucronatus, Pentagonia unisulcata, Parazyga hirsuta, Rhipidomella vanuxemi, Spirifer acuminata*, etc.). With these facts in view, it does not follow that the Black Shale ranges "from as low as the Onondaga." The *Buchiola retrostriata* fauna is a puzzle to stratigraphers other than Professor Williams. It comes to America as a migrant along an unknown path (there are three possibilities), appearing in part first in the Marcellus, recurring always with the Black shale conditions, and evidently is finally made up of other later migrants and stragglers from the American Hamilton faunas.

The sections and faunal lists of "Devonian sections in Central and Northern Pennsylvania" are given in great detail and have an especial value in connecting the type area of New York with the middle and southern Appalachians. For the first time, here is found a carefully collected sequence of Upper Devonic faunules; also the relation of the Catskill formation to the Chemung of Pennsylvania.

In conclusion, the writer will state that it is not shown that stratigraphers can not rely upon the fossil assemblages, as presented in these faunules, for definite correlation of formations over wide areas and especially within faunal provinces. The top and bottom of the correlated formations may not be everywhere exactly contemporaneous, yet for practical purposes they are fairly exact. It is true that the faunules are ever changing and that they are controlled to some extent by the character of the sediments (in some cases very largely so, and this is particularly true of the Black shale condition), but in nearly every faunule this constant change preserves a something by which its time position can be recognized. At times this something is the presence of a certain species, the dominance of a certain few species, the assemblage or absence of a certain species, controlled by the stratigraphic position of the faunule. It is known that many of the New York Hamilton Bryozoa and Ostracoda occur at the top of the Onondaga in the Falls of Ohio region, and Dr. Clarke has suggested that the top of the Onondaga limestone in New York probably is a tangential horizon, one end of which lies in Onondaga, the other in Marcellus time. Features further complicating these Devonic faunas, and to which but very few paleontologists have given attention, are the sources of the faunas, the paths of migration, and the barriers or low anticlines that originated at different times in the American Paleozoic epicontinental seas, resulting from Appalachian and Arkansas-Oklahoma movements.

Some conclusions resulting from the work recorded in this Bulletin are set forth by Professor Williams in another paper entitled "Bearing of some new paleontologic facts on nomenclature and classification of sedimentary formations" (Geol. Soc. Amer., 1905). His conclusions are at variance with the experience of other paleontologists, a fact clearly brought out in a recent discussion by the paleontologists of the U. S. Geological Survey (Stanton, Dall, Ulrich, and White) and summarized in Science, April 14, 1905 (pp. 583–585). CHARLES SCHUCHERT.

3. *Structure of some Primitive Cephalopods;* by R. RUEDEMANN. Rept. N. Y. State Pal., 1903 (April, 1905), pp. 296–341, pls. 6–13.—This very important and highly instructive paper treats in the main of the structure and development of *Endoceras brainerdi* of the lowest Ordovicic of the Lake Champlain region. It is shown that this primitive cephalopod begins with a protoconch followed by a long, gradually tapering, rather large and non-septate cone, as in Nanno and Vaginoceras. After attaining a length of about 70^{mm}, a slight constriction of the cone takes place and at this point it may be said that the wall of the cone divides, the inner division (or conchiolinous portion) to continue as the wall of the siphuncle (a continuation of the original cone cavity), while between it and the outer calcareous wall is developed the camerated space, or phragmocone. Within the siphuncle, after a few of the cameræ have been developed, there then appear other cones, the endocones, which communicate with one another by means of a central canal, or "endosiphuncular canal." The wall of the siphuncle rests against the recumbent edges of the cameræ walls until within a few inches of the terminal growth, where the cameræ (or "septal necks") form the lining to the large siphuncle opening directly into the living chamber. There are further siphuncular complicating structures about the endosiphuncular canal too complicated to be given here in a few words. However, it should be added that these developments led the author to a comparison of these structures with the Belemnites, and he concludes that the "endosiphocoleon" of endoceroids and the proöstracum in the Belemnites are "formed in identical places," i. e., "within a mantle flap or fold situated at the posterior end of the animal."

The author then discusses various early endoceran genera and concludes that the genera Cameroceras (syn. Endoceras) and Vaginoceras have earlier generic types for which he proposes Proterocameroceras and Proterovaginoceras. The latter is considered to contain the radical stock for these primitive forms. As Piloceras is closely related to these genera, the author also studied the development of this genus in *P. explanator*. From a study of this form he concludes that there is also here an earlier type with an external primitive cone, as in Proterocameroceras. To this very interesting but as yet undiscovered form, he gives the generic name Proteropiloceras, which of course no one is obliged to accept, under the rules of nomenclature. *Piloceras*

newton-winchelli Clarke is shown to be an Orthocerocone retaining Endocerocone structures, and is made the genotype of a new genus. This animal, therefore, bears the long and barbaric name *Clarkoceras newton-winchelli.* C. S.

4. *Notes on the Siluric or Ontaric section of Eastern New York;* by C. A. HARTNAGEL. Rept. N. Y. State Pal., 1903 (April, 1905), pp. 342–358.—This paper gives a clear exposition of the late Siluric deposits of southeastern New York and their correlation with the same horizons of the western part of the state. It is established that these deposits were laid down in two contemporaneous seas, a western or Mississippian sea and an eastern basin, the Cumberland. At times some of the species are common to the two waters, but as a rule each has its distinct fauna.

The Shawangunk, heretofore accepted as basal Siluric, is shown to be probably the basal or invading Salina sandstone in the Cumberland Basin. C. S.

5. *The Trilobites of the Chazy Limestone;* by PERCY E. RAYMOND. Ann. Carnegie Mus., III, 1905, pp. 328–386, pls. 10–14.—During the past five summers, Mr. Raymond has been studying the Chazy in the field, and here are presented his first laboratory results. All the known Chazy trilobites are described, 35 in number, of which 18 are new to the Chazy formation. A new subgenus *Glaphurus* is proposed. The genus *Ceraurus* is restudied, and the species referred to four divisions—*Ceraurus*, *Sphærocorphe*, *Pseudosphærexochus*, and *Nieszkowskia.* This paper should be studied in connection with one by the same author in the May number of this Journal.

The author brings out the interesting fact that the four orders of trilobites into which the class is divided are present in this old Ordovicic fauna; further, that the Chazy trilobites are closely related to those of the Trenton, and that three species are common to the two formations. With the Beekmantown below, there is far less agreement. C. S.

6. *Contributions to the Fauna of the Chazy Limestone on Valcour Island, Lake Champlain;* by GEORGE H. HUDSON. Rept. N. Y. State Pal., 1903 (April, 1905), pp. 270–295, pls. 1–5.—This is the first paleontologic publication of Professor Hudson, and describes 1 new cystoid, 3 crinoids, 2 brachiopods, 2 pelecypods, 6 gastropods, and 1 trilobite. C. S.

7. *Ueber Pteraspis dunensis* F. Roem. sp.; by F. DREVERMANN, in Marburg. Zeitschr. Deut. geol. Gesellsch., 56, 1904, pp. 275–289, pls. 19–21.—A very important paper on this Lower Devonic fish, based on many specimens recently discovered at Hamm, on the river Sieg, by Dr. Drevermann. C. S.

8. *Notice of a new Crinoid and a new Mollusk from the Portage rocks of New York;* by R. P. WHITFIELD. Bull. Amer. Mus. Nat. Hist., 21, 1905, pp. 17–20, pls. 1–4.—The crinoid is *Maragnicrinus portlandicus*, genus and species new. *Onychocardium portlandicum* is the new genus and species of bivalve. Remarks are also made on *Cyathocrinus ornatissimus*, which the author refers to *Cosmocrinus.* C. S.

9. *Fossils of the Bahama Islands, with a list of the non-marine mollusks;* by W. H. DALL. (The Bahama Islands, edited by G. B. Shattuck. See 12, below.) Geogr. Soc. Baltimore, 1905, pp. 23–47, pls. 11–13. In this paper are described a number of new species. The list of Bahama land shells, recent and fossil, has 171 species and varieties. Of marine fossil mollusks there are 51 species. The fauna of the "salt pans" has 12 species, of which 6 are peculiar to these lagoons. C. S.

10. *On the Relations of the Land and Fresh-water Mollusk-fauna of Alaska and Eastern Siberia;* by W. H. DALL. Popular Sci. Monthly, Feb., 1905, pp. 362–366.

11. *Geological Survey of Ohio*, Edward Orton, Jr., State Geologist. Fourth series, Bulletin No. 3. *The Manufacture of Hydraulic Cements;* by A. V. BLEININGER. Pp. xiv, 391. Columbus, Ohio, 1904.—The author has brought together in this volume a large amount of information relating to the different materials suitable for Portland cement and the methods of their manufacture. Much of the matter here given has not hitherto been accessible in English books. Attention is given particularly to the chemical side of the subject and the writer contributes also the results of his own researches.

12. *The Bahama Islands.* 630 pp. 93 plates. 7 figures. New York, 1905. (The Macmillan Company.)—This elaborate volume on The Bahama Islands is the product of an expedition of the Geographical Society of Baltimore, led in 1903 by Prof. Geo. B. Shattuck. Much assistance was received from several governmental Bureaus in Washington as well as from Johns Hopkins University in the way of instrumental and other outfit for the expedition. The volume treats the islands in all their aspects, scientific, hygienic, historic, economic; no less than fifteen authors contribute to its pages. The presence of water-filled caves to a depth of 300 feet and the discovery of recent bedded deposits with abundant marine fossils at heights up to 10 or 15 feet above sea-level in certain islands are taken to indicate former higher and lower stands of the land. Marine erosion, as well as preponderating submergence, is held responsible for the great diminution of a much larger former land area. The variety of soils, as indicated on soil maps of several islands, is greater than might be expected on a foundation of limestone alone. Pine-apples are the most important agricultural product; in some plantations they are grown in the little pockets weathered in the limestone surface. The history of the islands, with special regard to slavery, is given in detail. It was reported after the Baltimore conflagration that the Geographical Society was seriously affected by that disaster; but the issue of this handsome volume leads us to hope that the Society has only been temporarily affected, and that it will soon regain the vigor with which its career was begun. W. M. D.

13. *La Montagne Pelée et ses Éruptions;* by A. LACROIX. 4to. Paris, 1904 (Masson et Cie).—In this imposing and beau-

tifully illustrated volume, which is published by the Académie des Sciences of Paris, Prof. Lacroix, the chief of the French Scientific Commission sent to investigate the phenomena of Pelée and the general conditions attending the destruction of Saint-Pierre, presents his final report on his observations. This is the most extended study that has yet been made of the cataclysm of May, 1902, and of the volcanic phenomena of the island that followed upon this remarkable outburst. Much of what the volume contains has already appeared in advance papers published in the *Comptes Rendus*, and the conclusions advanced have also in large part been anticipated, both by the author himself and by the foreign investigators who preceded Lacroix in their investigations, but for all that the work stands as one of the finest contributions to vulcanology which geological literature contains, and it is to be hoped will be made a measure for future exploratory work of the same kind that may be initiated. On the main points connected with the now historic cataclysm, Prof. Lacroix holds generally to the views that have been advanced by the American investigators. The destroying blast of May 8 was an explosion of steam, with other gases, directed initially downward from the ancient crateral spot of the volcano, the Étang Sec, and has in kind been repeated a number of times since (the *nuées ardentes*), as on May 20, June 6, July 9, Aug. 30 (destruction of Morne Rouge) and other periods. Heated to a very high temperature, which may have reached 1500° to 2000° or more, densely charged with volcanic debris that it carried in its train, and descending with a velocity which at its point of impact with the unfortunate city is estimated to have been not less than 400 to 450 feet per second, it is not difficult to comprehend why the destruction should have been so absolute and far-reaching. In attributing the descent of the destroying "black cloud" to an initial explosive discharge whose direction was downward, and not to the attractive force of gravity, Lacroix stands in accord with virtually all the American investigators, and opposed to Drs. Flett and Tempest Anderson, representing the Commission of the Royal Society of London. The author is inclined to the belief that Saint-Pierre was annihilated in the space of a single minute, or perhaps even within a fraction of this time. As regards the construction of the remarkable Peléan excrescence which has been at various times described as "spine," "tower," "obelisk," and "needle," and which at its greatest development rose above its supporting dome by upwards of 1000 feet, Lacroix holds to his original views, somewhat modified in its details, that it represented a rapidly solidifying highly viscous (andesitic) lava, whose upward movement was conditioned by almost instantaneous solidification, and the impossibility under such conditions of taking the downward course of ordinary lava-streams. However much one may feel disposed to differ from this conclusion, the observations which have led to it are carefully stated, and form not the least important part of the work. A large part of

the volume is taken up with petrographical research, the author's own particular field of inquiry, which gives an interesting and most important vista into the theory of the formation of quartzitic rocks and the occurrence of free quartz in volcanic magmas.

ANGELO HEILPRIN.

Philadelphia, April 22, 1905.

14. *Recherches géologiques et pétrographiques sur l' Oural du Nord;* par L. DUPARC et F. PEARCE. Mem. Soc. Phys. d'Hist. Nat. Genéve, vol. 34, fas. 5, pp. 383–602. Pls. and map. 1905.—The first portion of this work was published in 1902 (ibidem, pp. 57–218) and gave a general description of the portion of the region in the Urals which had been studied (Rastesskaya and Kizelowskaya-Datcha, Govern. Perm.) Different parts of the area were then taken up in detail, the geology described and the petrography of the igneous rock formations presented, accompanied by numerous analyses. In the second memoir these detailed descriptions are continued, studies of the crystalline schists are also given, and the work concludes with observations on the structural geology and summations of the results obtained.

The chief interest centers on the masses of igneous rocks which have been investigated in the field and laboratory; they are chiefly of basic ferro-magnesian types, gabbros, dunites and pyroxenites. Of the latter a special type is described consisting of a foliated pyroxene with a variable amount of olivine and magnetite; the texture is granitic; the magnetite, playing the same role as quartz in a granite, forms the cement to the other minerals. To this rock the name of *koswite* is given. To another type which contains a certain amount of feldspar rich in lime, but which differs chemically from the gabbros, the name of *tilaite* is given.

The work is enriched by many figures and half-tones in the text, and is not only an important and valuable contribution to our knowledge of the Urals, but contains much in addition that is of general interest to geologists and petrographers. L. V. P.

15. *Einleitung in die chemische Krystallographie;* von P. GROTH. Pp. 80, 8vo. Leipzig, 1904 (Wilhelm Engelmann).—The author of this little volume has made so many important contributions to the subjects of Mineralogy and Crystallography, both separately and in their mutual relations, that it will not be a matter of surprise that the present volume, although brief in extent, is very helpful and suggestive in regard to the various topics it discusses. Its object, briefly stated, is to present the relations which exist between the properties of crystallized bodies and their chemical constitution as based upon a definite theory as to the structure of crystals. It is, moreover, introductory to an exhaustive work in preparation by the author, in which it is proposed to give a systematic and critical presentation of crystal forms and the physical properties of crystallized substances.

16. *Grundzüge der Krystallographie;* von Prof. C. M. VIOLA. Pp. x, 389, 8vo. Leipzig, 1904 (Wilhelm Engelmann).—This

volume is based upon the course of lectures which the author has delivered at the University in Rome. The subject, however, has been much expanded and developed, and now presents the Crystallography of the present day as viewed by the author, from a standpoint at once advanced and theoretical. The student whose interests lie in this, rather than in the strictly practical side of the subject, will find this work worthy of careful study.

III. Miscellaneous Scientific Intelligence.

1. *The Ascent of Water in Trees;* by Alfred J. Ewart (abstract of a paper read before the Royal Society of London).—As the result of a series of experimental observations bearing upon this problem, the author has been led to the conclusions stated in brief below.

The flow of water through open vessels filled with sap takes place in accordance with Poiseuille's formula for the flow through rigid cylindrical tubes, divergences being due to the presence of irregular internal thickenings in the vessels, and to local constrictions or deviations from the circular outline.

Hence the velocity of flow is directly proportional to the pressure and to the square of the radius of the tube, inversely proportional to the length of the tube and to the viscosity of the liquid. A small number of large vessels, therefore, offer very much less resistance to flow than a large number of narrow ones having the same length, and the same total internal area of cross-section. Since viscosity is largely dependent upon temperature, the latter forms an important factor in regulating the flow, the viscosity and the resistance falling with a rise of temperature.

With an average rate of flow the total resistance due to the viscosity of the water flowing through the vessels is always less, and in climbing plants with large vessels is considerably less, than a head of water equal in height to the stem. The adult vessels of actively transpiring angiospermous trees always contain air-bubbles, and these introduce a resistance to flow which is inversely proportional to the radius of the tube, when the air-bubbles and the water-columns move together. When the air-bubbles are comparatively stationary, as in most vessels, the resistance is still further increased, and it becomes very great when the vessels are small and the air-bubbles numerous. In intact vessels containing air the rates of flow under similar pressures are proportional to a power of the radius lying between 1 and 2, the volume passing to a power of the radius lying between 2 and 4.

Estimations of the amount of flow, made from the rate of flow and the diameters and number of the vessels, showed that the actual flow takes place in the wood of dicotyledons almost entirely through the cavities of the vessels and hardly at all through the tracheides. In young stems saturated with water under pressure, a considerable flow takes place through the pith, but practically none in intact transpiring stems.

In a cut stem, apart from the blocking at the cut surfaces, a gradual diminution of conductivity occurs along its entire length after water has been passed through for some time. This appears, in part at least, to be due to the development of micro-organisms in the vessels, but may be aided by swelling, by lessened permeability, or by other changes in their walls.

The length of the vessels in the wood of the branches examined averages from 7 to 36 centimeters, the tracheides of the yew being from 0·2 to 0·5 of a centimeter in length. Since, however, the vessels appear mainly to end at the nodes where branches arise, it is possible that they may be much longer in the young wood on old bare trunks. The resistance to transverse flow through saturated wood is 800 to 45,000 times greater than to longitudinal flow, the resistance to filtration under pressure through a single partition wall being from 2 to 10 times greater than that to the flow through the entire length of a vessel filled with water in the wood of a crab apple.

The total resistance to flow in the erect stems of actively transpiring plants appears to correspond to a head of water of from 6 to 33 (shrubs and small trees), or from 5 to 7 (large trees) times the height of the plant. Hence in the tallest trees the total pressure required to maintain active transpiration may be equivalent to as much as 100 atmospheres.

No leaf could produce or maintain an osmotic suction of this intensity, and in the presence of large air-bubbles in the vessels the stress transmitted in them from the leaves could never be as great as an atmosphere. Vines* found, for instance, that the suction force of a transpiring branch was never greater than two-thirds of an atmosphere. The supposition that these forces might summate is entirely erroneous. On the contrary, the leaves at the base of a tree would pull water down from the upper vessels and leaves, instead of up from the roots, in the absence of any pumping action in the stem, and of any root-pressure.

If the air-bubbles in the vessels were exceedingly minute, they might be under a small positive pressure, while the water outside was under a maximal strain of five atmospheres. This would suffice to overcome the resistance offered during active transpiration by 30 to 80 feet of stem, hence the results obtained by Strasburger with dead stems. The maximal osmotic suction exercised by the leaves, as determined by comparing the osmotic pressures during active transpiration of the leaves at the top and bottom of an elm 18 meters high, appears to be from 2 to 3 atmospheres, and is usually less than this. At the same time the total resistance to flow in the trunk of this tree would be from 10 to 12 atmospheres.

It appears, therefore, that to maintain flow, a pumping action of some kind or other must be exercised in the wood, for which the presence of active living cells is essential. In support of

* Annals of Botany, 1896, vol. x, p. 438.

this it has been shown that the production of wood in a slowly growing tree is greater than is necessitated by mechanical requirements. In other words, the production of new wood is largely determined by the length of time during which the wood-parenchyma can remain active.

There is no known means by which these cells can directly pump water in a definite direction, although the existence of a power of absorbing and exuding water under pressure has been empirically determined to exist in the living wood of cut branches. It is suggested that the wood-parenchyma cells by the excretion and re-absorption of dissolved materials may bring into play surface-tension forces within the vessels of sufficient aggregate intensity to maintain a steady upward flow, and to keep the water of the Jamin's chains in the vessels in a mobile condition ready to flow to wherever suction is exercised upon it.* The rapid rates of diffusion required for such action do actually exist in the wood-parenchyma cells.

It appears that the terminal branches of trees at heights of from 22 to 44 feet above ground exhibit little or no power of bleeding in spring. Possibly in such trees the pumping action is only used or developed in the wood of the older stems, or is only exercised when transpiration is active, and when the water-columns in the vessels attain a definite size relatively to the wood-parenchyma cells. The importance of the Jamin's chain in the vessels is that it renders a staircase-pumping action possible, and enables the water to be maintained in the vessels in a labile condition, ready to flow to any point where moderate suction is exercised. This pumping action being diffused and probably regulated, need not produce any high pressure of exudation at the terminal branches of tall trees, which, in fact, appears always to be absent at high levels.—*Proc. Roy. Soc.*, lxxiv, 554.

2. *Problems of the Panama Canal;* by Brig.-Gen. HENRY L. ABBOT, U. S. Army, retired. 248 pp. New York, 1905 (The Macmillan Co.).—The position occupied for so many years by General Abbot in the Engineer Corps of the United States Army, and also his official connection with the new French company for the Panama Canal established in 1894, have made him particularly fitted to give an accurate and thorough presentation of the more important scientific problems involved in the present and future work on the Canal. The volume is a particularly timely one, and will be read with interest by the general public, as well as by those more immediately concerned. A brief historical introduction is given, followed by a chapter on the relative advantages of the two routes which have been discussed; to that of Panama unqualified approval is given. The bulk of the work, however, is devoted to the consideration of the peculiar physical conditions existing on the Isthmus, particularly those affecting

* Surface-tension actions would be possible in the absence of air-bubbles wherever the wood-parenchyma cells contained oil or any other substance non-miscible with water, as they often do.

the prosecution of the work. These include chiefly the range of temperature during the different seasons of the year, and still more the amount and distribution of the rainfall; full details with numerous tables are given in both these directions. In connection with the latter subject, the hydraulic problems involved in the regulation of the Chagres River are discussed at length, and with the same thoroughness which characterizes the other parts of the work. The conclusion is reached that although the matter presents serious difficulties, they are not greater than those that have been met with elsewhere, and that "all that is required is a judicious plan of regulation based on well-established principles." With respect to the question that has arisen between a sea-level canal and one provided with a series of locks, the author speaks very emphatically in favor of the latter, on general grounds, as also because of the economy in time and money.

3. *A Primer of Forestry. Part II, Practical Forestry;* by GIFFORD PINCHOT, Forester. 88 pp., 12mo, Washington, 1905 (Bulletin No. 24, Part II, U. S. Dept. of Agriculture, Bureau of Forestry).—This little book, like its predecessor, presents the practical problems of forestry in most clear and attractive form. Indeed, brief as it is, the subject is put before the reader so conclusively that it seems difficult to understand why scientific methods are not everywhere employed in dealing with nature's effort to provide humanity with a lasting supply of useful woods, instead of the short-sighted policy so common in this country. The situation has improved materially since the Department of Forestry was organized, and greater progress through the enlightenment of the public is promised for the future.

4. *Field Operations of the Bureau of Soils, 1903.* Fifth Report. By MILTON WHITNEY, Chief, with accompanying papers by assistants in charge of field parties. 1310 pp., with 3 plates, 61 text figures and 78 maps in separate portfolio case. Washington, 1904 (U. S. Department of Agriculture, Bureau of Soils).—During the season of 1903, a total area of 26,543 square miles was surveyed and mapped by the various parties of the Bureau of Soils; this was divided over 61 separate areas, averaging 437 square miles each, in 37 states and territories. The detailed results of this extensive work are contained in these volumes recently given to the public.

5. *Mechanism;* by S. DUNKERLEY. 408 pp. New York and London, 1905 (Longmans, Green & Co.).—This book, while not designed to be a philosophical treatise on pure mechanism, is valuable for its many and modern applications of various machines. The first two chapters, including the introductory one, discuss the simpler types of machines and shop appliances, as well as combinations of belting and gearing. The more complete study of gearing and gear teeth is left to a later chapter. The geometrical properties of mechanism are next taken up with machines whose interest lies particularly in the paths traced by their parts. Steam engine indicators are conspicuous examples

described in illustration. One chapter embraces velocity-ratio diagrams and approximate solutions of link motions. Valve and steering gears, together with various link motions, are given here to exemplify. Another chapter is devoted to acceleration diagrams, which with the velocity-ratio diagrams, are most important in the study of the dynamics of machines. The subject of toothed circular and non-circular wheels is comprised in the last half of the book. The kinematic conditions which must be satisfied by profiles of teeth and methods mechanical and graphical for determining their shapes are fully given. Problems illustrate the text throughout. For a lecture course on the kinematics of machines this book would make an accompaniment for which it is well adapted. C. B. R.

6. *British Museum of Natural History: Guide to the Gallery of Birds in the Department of Zoology.* 228 pp., with 24 plates and illustrations. London, 1905.—This guide has been prepared by Mr. W. R. OGILVIE-GRANT, Assistant in the Zoological Department, who has also carried out the arrangement of the collections as now exhibited. An appendix is added on the structure of birds with illustrations of the feathers and skeleton. The numerous full-page plates give reproductions of excellent photographs of actual specimens in the gallery. To those who have not had the opportunity to learn by actual visit the riches of the Museum they will give a good idea of the admirable results attained in the representation of birds in their natural surroundings.

7. *Catalogue of the Lepidoptera Phalænæ in the British Museum*, Vol. V. *Catalogue of the Noctuidæ;* by SIR GEORGE F. HAMPSON. Pp. xvi, 634, with plates lxxviii–xcv. London, 1905.—The publication of the fourth volume of this important work was noticed in the number for February, 1904. The present volume embraces the classification of the Hadeninæ, the second of the fifteen subfamilies of the Noctuidæ; 946 species belonging to 78 genera are described. This subfamily is characterized by its trifid neuration of the hind wing, combined with the hairy clothing of the eyes.

8. *Geographen-Kalender; in Verbindung mit vielen Fachgenossen herausgegeben* von Dr. HERMANN HAACK. Dritter Jahrgang, 1905–1906. 468 pp. Gotha, 1905 (Justus Perthes).—The third issue of this useful calendar contains the good features of its predecessors with some additions and emendations. The address list of geographers and those in allied departments has been much enlarged and made more accurate. The literature of the year 1904 is fully treated, as also the necrology; further, a brief summary is given of interesting events illustrated by a series of sixteen maps. A portrait of Jacques-Elisée Reclus forms the frontispiece.

9. *Publications of the Carnegie Institution.*—The following papers have been recently issued:

No. 23. Heredity of Coat Characters in Guinea-Pigs and Rabbits; by W. E. CASTLE. 78 pp., 6 plates (Papers of Station for Experimental Evolution at Cold Spring Harbor, N. Y., No. 1).

No. 24. Mutants and Hybrids of the Oenotheras; by D. T. MacDougal, assisted by A. M. Vail, G. H. Shull and J. F. Small (Cold Spring Harbor Papers, No. 2). 57 pp.

No. 28. A revision of the Atomic Weights of Sodium and Chlorine; by Theodore W. Richards and Roger C. Wells. 70 pp.—See notice on p. 451.

No. 29. The Color Sensitivity of the Peripheral Retina; by John Wallace Baird. 80 pp.

No. 30. Stages in the development of *Sium cicutæfolium;* by George Harrison Shull. 28 pp. (Cold Spring Harbor Papers, No. 3).

A study of the Conditions for Solar Research at Mt. Wilson, California; by George E. Hale (Contributions from the Solar Observatory of the Carnegie Institution, Mt. Wilson, California, No. 1). 27 pp.—A careful investigation of the climatic conditions upon Mt. Wilson, near Pasadena, California, shows that it offers very great advantages for astronomical work, particularly in the study of the sun and solar radiation. Professor Hale remarks that he knows "no other site that compares at all favorably with it." It is much to be hoped that the plans for the building and equipment of a large solar observatory at this point may be carried rapidly to completion.

10. *Cold Spring Harbor Monographs.* III, The Salt-Marsh Amphipod: Orchestia palustris; by Mabel E. Smallwood. 21 pp. with two plates and a map. Brooklyn, March, 1905. Published by the Brooklyn Institute of Arts and Sciences.

11. *Science Bulletins of the Brooklyn Institute of Arts and Sciences.* Published by the Macmillan Company—The following numbers of volume I have appeared under date of March 31:

No. 5. Mammals from Beaver County, Utah, collected by the Museum Expedition of 1904; by J. A. Allen. Pp. 117–122.

No. 6. Additions to the Coleoptera of the United States with notes on some known species; by Chas. Schaeffer. Pp. 123–140.

12. *Project for the Panama Canal;* by Lindon W. Bates. 38 pp., with several maps and plans.—The author discusses briefly some of the projects that have been proposed for the canal and then presents in full the one which in his judgment is likely to lead to the best results. General plans and profiles are given of the water way, the regulation works, and the terminal harbors.

Obituary.

Henry R. Medlicott, F.R.S., the eminent English geologist, died on April 6 at the age of seventy-six years. His work was chiefly in connection with the Geological Survey of India, which he joined in 1853 and of which he was the Director from 1876 to 1887.

Professor Pietro Tacchini, the celebrated Italian astronomer, died at Spilamberto, Modena, on the 24th of March, at the age of sixty-seven years.

Professor Otto Struve, Director of the Pulkowa Observatory from 1862–1890, died on April 14, at the age of eighty-five years.

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